Going Beyond Paper Parks in Marine Conservation:

The Role of Institutions and Governance of Marine Reserves in the Gulf of California, Mexico

by

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ABSTRACT

In the face of increasing anthropogenic threats to marine systems, marine reserves have become a popular tool to promote sustainable fisheries management and protect marine biodiversity. However, the governance structures that determine marine reserve success are not well understood. The response of resource users to reserve establishment, as well as the socioeconomic, institutional, and political contexts in which they occur, are rarely considered during reserve implementation. I use the Coupled Infrastructure Systems (CIS) framework to better understand the interdependencies between social, economic, natural, and institutional processes affecting reserve implementation and performance efficacy in the Gulf of California, Mexico. I used a combination of interviews, qualitative case study comparisons, and systematic conservation planning tools to evaluate the role of different infrastructures, institutions, and governance for marine reserve efficacy in the Gulf of California, Mexico. At a local scale, I assessed stakeholder perceptions, preferences, and knowledge on reserves in the Midriff Islands sub-region of the Gulf. My results show differences in fisher perceptions about the use of reserves for biodiversity conservation and fisheries management, misconceptions about their location, and non-compliance behavior problems. At the regional scale, I explored the trajectories of reserve implementation and performance. I show that capacity-building programs and effective collaboration between non-profit organizations, environmental, fisheries, and other government authorities are essential to coordinate efforts leading to the provisioning of infrastructure that enables effective marine reserves. Furthermore, these programs help facilitate the incorporation of fishers into diversified management and economic activities. Infrastructure provision tradeoffs should be carefully balanced for designing scientifically-sound reserves that can achieve fisheries recovery objectives and incorporating stakeholder engagement processes during the planning phase that allow fishers to include their preferences in a way that complements proposed reserve network solutions. Overall, my results highlight the importance of multiple infrastructures in understanding the dynamics of interacting action situations at various stages of marine reserve implementation and operation. I identify strengths and weaknesses within marine reserve systems that help understand what combinations of infrastructures can be influenced to increase marine reserve effectiveness and robustness to internal and external challenges, as well as delivering benefits for both nature and people.

DEDICATION

In loving memory of my grandparents Maria del Socorro and Claudio.

To my parents Maria del Mar and Héctor for being my inspiration, for being exemplary role models, and for always supporting me in my decisions and my journeys.

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CHAPTER 1

UNDERSTANDING EFFECTIVENESS OF MARINE RESERVES THROUGH A COUPLED INFRASTRUCTURE SYSTEMS LENS

1.1 Introduction

Given the pressing challenge of maintaining fishery resources in the face of growing human population and anthropogenic threats, marine protected areas (MPAs), specifically marine reserves (or no-take areas), have become a popular fisheries management tool (Fraschetti et al. 2011). The growing literature on marine reserves includes ample data on the benefits they provide, what works with regards to their design and maintenance, and key challenges for achieving objectives. However, marine reserves occur within particular socioeconomic and historical contexts that limit what they can accomplished, and these dimensions are less swell-studied. Therefore, there is an urgent need to pay attention to the combinations of the ecological, cultural, institutional, and socioeconomic characteristics and operating conditions of marine reserve systems to ensure acceptance by stakeholders and successful outcomes.

Marine reserve goals, objectives, and implementation processes vary within sociopolitical and geographical contexts. Some are motivated by conservation of biodiversity and critical habitat protection whereas others focus on the achievement of sustainable harvest of important species for traditional, subsistence, or commercial use. Large-scale MPAs can also be part of ecosystem-based management strategies, in which they may be designed to achieve a broad range of objectives (Fernandes et al. 2005). Marine reserves can be designed via top-down initiatives (i.e. through the federal or state government), bottom-up initiatives (i.e. via local community arrangements), or a combination of both, and their decision-making can also vary from centralized to de-centralized systems. This variability in needs and strategies is a product of the biological, socioeconomic, institutional, and cultural site-specific conditions surrounding every particular ecological system. In other words, context matters.

Given the diversity of marine reserve design and management strategies worldwide, it is clear that there is no single model for marine reserves that can fit all circumstances and be universally applicable (Agardy et al. 2003), and in continuing to search for such a model we risk conflict (Jentoft et al. 2007) and limited success if the context in which marine reserves function is not carefully considered. In this chapter, I explore the potential for using existing frameworks from the governance and institutional analysis fields to understand what are the main drivers of efficacy of marine reserves at achieving their objectives and providing benefits to both nature and people. I first review the literature on effective marine reserve design from the perspective of multiple disciplines. I then summarize the efforts made by the common pool resource and institutional analysis literature to understand outcomes of collective action, followed by a description of the Coupled Infrastructure Systems (CIS) framework as a conceptual model to understand effective outcomes of shared resource governance in the context of marine reserves. Finally, I conclude with a hypothetical example of how the CIS framework can be applied to any marine reserve system.

1.2 Efforts to address efficacy in marine reserves

Up until the last decade, marine reserve goals were often stated under ecological terms with social and economic goals and human benefits listed as secondary consequences of achieving the former (Jentoft et al. 2007). From a biological perspective, there is a growing literature on guidelines for designing effective marine reserves to achieve multiple objectives with regards to fisheries management, conservation of biodiversity, and adaptation to changes due to climate change simultaneously (Green et al. 2014). These guidelines includes a combination of established criteria for achieving a successful marine reserve: habitat representation (diversity/complexity), habitat replication, risk spreading, protecting critical, special, and unique areas, reserve size, reserve spacing between reserves (connectivity), life history and ecological traits, location (activities taking place outside of the reserve), and duration (Fernandes et al. 2009, Fernberg et al. 2012, Saarman et al. 2013, Green et al. 2014).

Efforts to identify clear guidelines on how to design marine reserves that address economic, social and governance considerations simultaneously with biological effects have been less streamlined. Jentoft et al. (2007) define MPAs from a governance perspective as "complex social institutions that aim to influence human behavior", and as such, they are part of a larger social system with institutions, rules, norms, and values of its own. Furthermore, two of the main challenges include identifying how to we define a "successful marine reserve", and how can we understand and assess the importance of contextual variables for marine reserve efficacy. Furthermore, the state of contextual variables (i.e. those that remain constant for a given analytical study but not across studies) can affect the impact of the variables being explicitly studied in real world situations (Agrawal 2003).

1.3 Socioeconomic characteristics and human dimensions of marine reserves

Consideration of incentives driving fisher behavior and how fishers are likely to respond to marine reserve establishment has been recognized within the literature on the economics of fisheries as highly relevant for marine reserve establishment (Sanchirico and Wilen 2001, Sanchirico et al. 2006). Econometric modeling approaches in conjunction with spatially explicit biological population models show how fishers respond to differences in expected returns across different patches, as well as responding negatively to weather risk and travel distances and positively to expected returns (Smith and Wilen 2004). These studies highlight the importance of fisher spatial and economically motivated behavior to prevent biased predictions of marine reserves toward optimistic harvest gains and net economic costs of implementing reserves (Smith and Wilen 2003). Furthermore, discrete choice models of fisher behavior have demonstrated the importance of considering the short-run and long-run opportunity costs of NTAs to fishers, which depend on the availability of fishing opportunities in alternative sites and other sources of income (Smith et al. 2010). Whether these costs are outweighed by perceived long-term benefits also depends on ecological (e.g. habitat quality, stock abundance, dispersal) and fisher-specific considerations (e.g. non-fishing income, fishing skills) (Smith et al. 2010). These results support the idea that if the current opportunity costs of fishing are high (i.e. if there are good opportunities elsewhere) and if fishermen perceive longer term benefits (e.g. stock growth outside the reserve), fishermen would be less likely to oppose the implementation of the marine reserve.

Much of the research on the human dimensions of marine reserves consists of small-scale case studies over a specific geographical area. There is a great body of literature that focuses on examining the social context in which long-enduring sociocultural institutions (e.g. customary marine tenure systems that implement spatial or temporal closures) limit marine resource use in coastal communities. These small-scale studies have looked at questions on social processes influencing traditional closures (Cinner et al. 2005), the acceptance of marine reserves (Charles and Wilson 2009), the relationships between socioeconomic factors and marine tenure (Cinner 2005) as well as with community-based management participation (Gurney et al. 2006), the effectiveness of community-based resource management approaches to marine reserves (Aswani and Weiant 2004, Crawford et al. 2004, Cinner 2007), and informal institutions and traditional management practices (Colding and Folke 2001). Studies have also looked at issues related to compliance with marine reserves (e.g. in Costa Rica (Arias et al. 2015) and Australia (Arias and Sutton 2013)), perceptions of fisher displacement and reserve spillover in Kenya (Cinner et al. 2014) and of MPA livelihoods, governance, and management processes in Thailand (Bennett and Dearden 2014b), social inequity and its consequences for MPAs in Indonesia (Gurney et al. 2015), and success of "bottom-up" community-based fishery management with temporal fishing restrictions over "top-down" government established marine reserves (Kareiva 2006, McClanahan et al. 2006).

Large-scale studies systematically analyzing the marine reserve literature and multiple case studies have also made progress towards identifying important socioeconomic factors that relate to the efficacy of marine reserves on a global scale (e.g. Caribbean, the Philippines, and the Western Indian Ocean) Pollnac et al. (2010), addressing solutions for bridging the divide between MPA management and fisheries sustainability (Weigel et al. 2014), compliance with marine reserves worldwide (Bergseth et al. 2015), clearer metrics for defining protection and assessing progress of marine reserves (Spalding et al. 2016), and local development, management, and governance inputs leading to effective MPAs through an Inputs Framework (Bennett and Dearden 2014a), and a Marine Protected Area Governance (MPAG) Framework (Jones 2014).

1.4 Common pool resources, social-ecological systems, and coupled infrastructure systems

The literature on Common Pool Resource (CPR) management provides us with a numerous list of case studies on communities managing CPRs within a variety of institutional arrangements (i.e. clusters of rules specifying allowed or required actions, accessible information, and how costs and benefits are related to actions and outcomes, (Ostrom et al. 1994)) have successfully managed to solve social dilemmas in which two or more people can benefit collectively from cooperation but also benefit individually from freeriding (Ostrom 1990). The evidence provided by this body of literature was made possible with the development of the Institutional Analysis and Development (IAD) framework (Kiser and Ostrom 1982), originally developed as a way of understanding the process of policy-making, and analyzing institutions governing action as well as the outcomes of collective action arrangements Ostrom (1990).

Following the development of the IAD framework, the concept of social-ecological systems (SESs) became popular among CPR scholars to reflect the interactions between the biophysical elements of a resource system and humans (Berkes and Folke 1998), as well as more recently adding the role of human-made hard and soft infrastructure (Anderies et al. 2004, Ostrom 2007, 2009, Anderies and Janssen 2013). Scholars continued to develop extensions of the IAD framework to further highlight the relationships between institutions and ecological systems in the face of uncertainty as well as the practical implementation of these ideas for interdisciplinary research. Anderies et al. (2004) developed the "Robustness for Social-Ecological Systems" framework to understand the broad structure of the components of a SES, their connections, and how their interactions affect the SES's long-term robustness (i.e. it's ability to cope with uncertainty and disturbances from both inside and outside of the system) from an institutional perspective (Anderies and Janssen 2013). The Social-Ecological Systems framework (formally known as the "Multitier framework for analyzing SES" (Ostrom 2007) and the "Framework for Analyzing Sustainability" (Ostrom 2009)) were then developed within several iterations to equally consider the biophysical and ecological foundations of institutional systems through the identification of a large number of broadly applicable variables arranged in a nested tier system (McGinnis 2011). A significant number of valuable insights that have been gained from applying frameworks that stem from this concept towards understanding the importance of institutions (i.e. rules, norms, and strategies that humans use to dictate their interactions) to engage in collective action in order to avoid resource overexploitation (Becker and Ostrom 1995, Basurto and Coleman 2010). Finally, the CIS framework was introduced in 2015 (ADD Anderies 2015) as an extension of the IAD and the Robustness frameworks to redefine the basic unit of analysis (from action situations to CISs) to which institutional analysis is applied, highlight the complex web of interactions within a system and the feedbacks generated by its linked components, and emphasize the importance of the concept of *infrastructure* for addressing governance of shared resources (Anderies 2015, Anderies et al. 2016).

Before examining ways that the CIS framework can be applied to understand governance considerations in the context of marine reserve systems, some of the features of the components of the IAD framework are worth taking a closer look to exemplify their relevance within the marine reserve domain. The core component and basic unit of analysis of the IAD framework is defined by an *action situation* as a conceptual unit where two or more individuals (acting on their own or as members of an organization) are exposed to information, face a set of potential actions, and engage in patterns of interaction that jointly produce outcomes (Ostrom 2005, McGinnis 2011). Action situations have a specific structure that can be described and analyzed by a common set of variables and their respective institutional arrangements. Table 1.1 shows three examples of action situations related to marine reserves at different levels of analysis. To illustrate how an action situation is structured, I describe in detail the example at the collective choice level from Table 1.1 (Figure 1.1).

While in practice collective choice processes in marine reserve planning are known for being substantially complex, involving numerous meetings, negotiations, and iterations of the processes occurring within, the following example describes a hypothetical case that aggregates these processes and summarizes the key structural variables of the action situation as a whole. Broadly speaking, individual actors can assume specific positions within the various stakeholder sectors that are active in that region, be somehow elected to participate in these meetings given their sector's boundary rules (i.e. specifics on how participants enter or leave a position), and the specific actions actors in such positions can take (i.e. through choice rules).

Table 1.1. Examples of action situations within the context of marine reserves at the different levels of analysis. * = adapted from (Ostrom 2005).

Level of analysis	Description *	Examples
Constitutional choice	Where higher level collective choice processes and rules are defined to structure other action situations and the collective choice rules they operate with.	• Federal legislators making decisions about: ○ Procedures for officially decreeing marine reserves (e.g. who can participate in formal stakeholder committees, or what studies need to be made to justify the establishment of a marine reserve). ○ Deciding whether current proposals for marine reserve become approved to become implemented.
Collective choice	Where institutions are constructed and decisions are taken among the set of actors authorized to participate in the process (according to the procedures established at the constitutional choice level.	A formal stakeholder committee where representatives of each stakeholder sector come together to discuss and make decisions (e.g. zonation, uses allowed) over a proposal to implement a marine protected area with a number of marine reserves inside as well as areas for exclusive fishing rights to locals of the neighboring community.
Operational	Actors interacting and implementing practical day-to-day decision within an action situation are influenced by the incentives they face to generate outcomes (as allowed by the collective and constitutional choice processes).	Small-scale fishers withdrawing fish from a marine protected area where fishing is allowed but adhering to specific gear restrictions to avoid harming endangered species that inhabit the area.

For example, a fisher representative from the local small-scale fishing cooperative may have been elected given his/her local status and membership on the cooperative, and thus invited to participate in these meetings given his connection to the local small-scale fisher sector. A director of conservation management from the state conservation management agency may have been elected given his/her long trajectory within the public sector for conservation management, and thus invited given his authority to endorse marine reserve proposals for state or federal decree. A scientist from the local academic institution may be recognized for his/her academic achievements and publications, and thus be invited to provide technical and scientific information relevant for the marine reserve proposal. Finally, a chief manager of marine reserve affairs within a non-profit organization may have been elected to his/her position given his expertise in facilitating stakeholder meetings for marine reserve affairs.

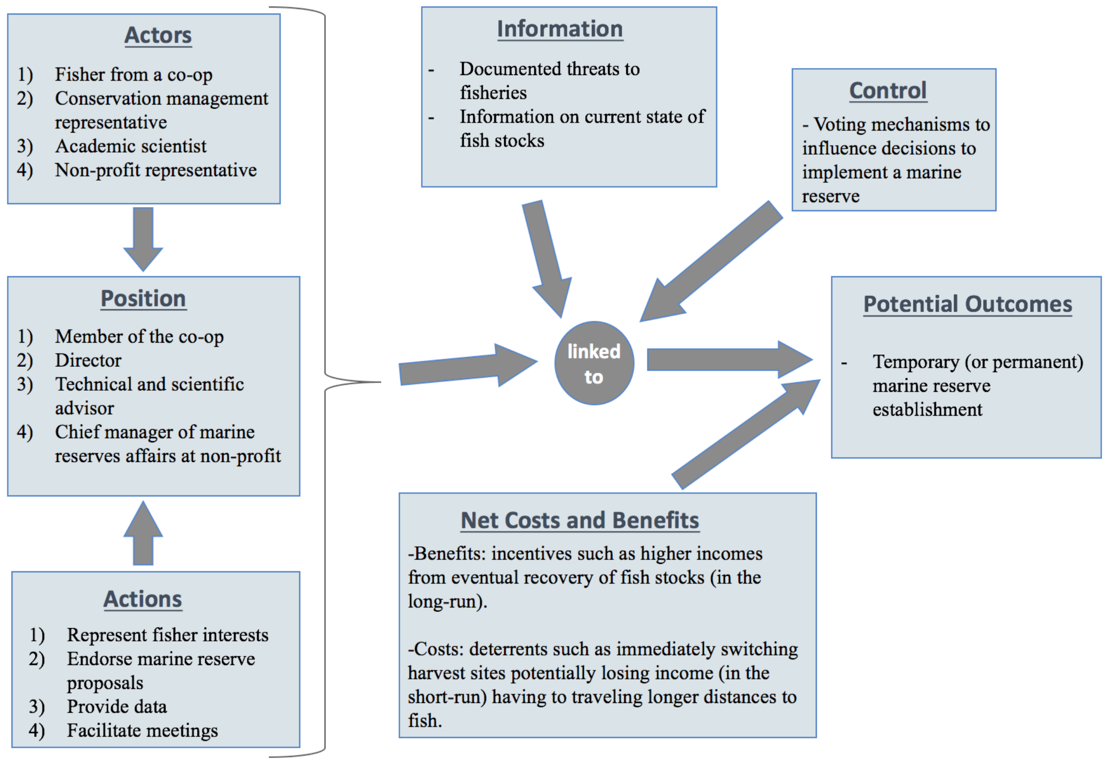

Figure 1.1. An action situation for an example on stakeholder committees discussing proposals for marine reserves. Adapted from (Ostrom 2005).

The positions of the actors and their actions lead to interactions and outcomes related to whether stakeholder groups in a community choose to endorse the implementation of a marine reserve in their region, and if so how they endorse it. These choices are linked to the potential outcomes through the level of information actors possess (e.g. how much access these groups have to information on fish stock trends and documented threats to fisheries so they can make informed decisions) and how much control these actors have over how their decisions can become outcomes (e.g. whether there are specific voting mechanisms within the stakeholder committee that may influence the final decision to implement the marine reserve). However, they are also bound by the potential set of outcomes that are realistic and feasible within the specific context (e.g. whether the proposed marine reserve is temporary or permanent according to the region's legal instruments for marine reserves). Finally, the actors' choices are also related to how they perceive costs and benefits from potential outcomes (e.g. what are the incentives and restrictions of implementing a marine reserve). This characterization of the *action situation* can be used to describe, analyze, and explain the likely behavior of the actors in such a structure (Ostrom 2011) and can set the stage for further evaluation of the current institutional arrangements governing marine reserve management.

The IAD framework also considers external variables (i.e. contextual factors within which an action situation exists) such as the biophysical conditions of the system (e.g. the type of habitat being proposed for protection within a marine reserve), the attributes of the community (e.g. heterogeneity, size, and cultural characteristics of the communities affected), and the rules of the current institutional context (e.g. official existing rules for fisheries management such as fishing permits, fishing concessions or gear restrictions, as well as unofficial rules such as fisher-proposed seasonal closures for a specific species). These external variables are processed within the action situation through recursive interactions to produce outcomes that can then be evaluated. These outcomes can produce both a fast feedback effect to influence how participants of the action situation implement practical decisions (influencing operational level action situations through the faster inner loop), and a slower feedback effect influencing how multiple operational level action situations that are related to management interact with collective choice level action situations related to providing public goods (Anderies et al. 2016).

1.5 The Coupled Infrastructure Systems lens

Within the CIS framework (Figure 1.2), infrastructure is defined as any "coherent structure[s]...that can manipulate mass, energy, and information flows...that combined can provide affordances [i.e. accessible possible outcomes to individuals] to produce a variety of mass and information flows we value...[and that] require investment...to [be] produce[d] or maintain[ed]" (Anderies et al. 2016). The CIS framework considers five different types of infrastructure that can directly map into the external variables identified within the IAD framework.

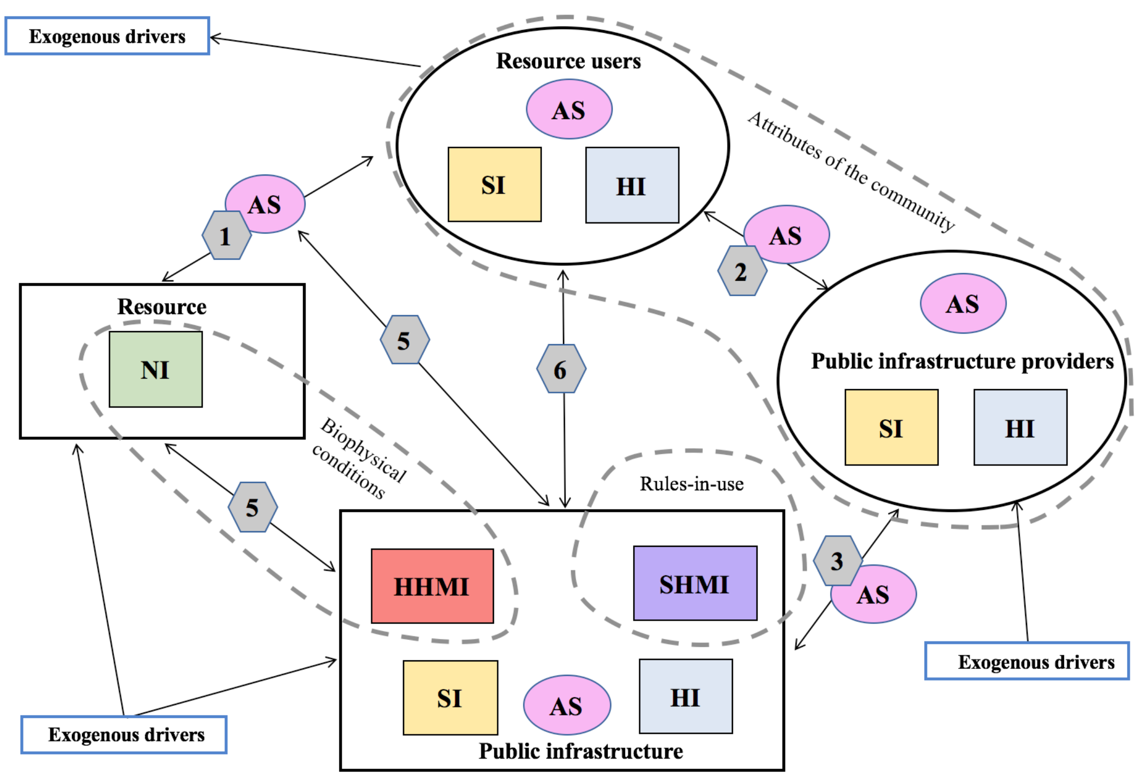

Figure 1.2. The Coupled Infrastructure Systems (CIS) framework. Adapted from Anderies et al. (2016). AS = Action Situation; S = Spillover (or links). See text for further explanation.

1) *Natural infrastructure* (NI) is considered hard infrastructure that includes the resource itself (e.g. commercial fish and invertebrate species targeted by both small-scale fishers and industrial fishers) as well as the ecological (e.g. coral reef habitat patches or an enclosed bay harboring multiple habitats such sandy bottom, rocky reef and *Sargassum* forests within) and biophysical components (e.g. oceanographic patterns and ocean circulation resulting in asymmetric connectivity between patches) that characterize the ecosystem.
2) *Hard human-made infrastructure* (HHMI) includes human-made structures (e.g. fishing vessels and their motors, fishing gear such as nets and traps, processing and storage plants with freezer equipment, docks, equipment for biological monitoring and census data processing).
3) *Soft human-made infrastructure* (SHMI) includes human-made guidelines or instructions for using other types of infrastructures (e.g. the legal system allowing marine reserves to be established, legislative documents outlining fishing regulations or procedures for the establishment of a marine reserve, official federal decrees of marine reserves and their management programs, guidelines from experts with regards to best practices for designing marine reserves, unofficial agreements among fishers to avoid certain practices or not using certain gear to fish for a specified amount of time).
4) *Human infrastructure* (HI) includes the knowledge, levels of experience, and capacities of a particular group of people or community (e.g. fishers with over 40 years of experience fishing in a particular area, education levels of fishers, individuals

demonstrating exceptional leadership skills and management capacities, or particular skills for finding and catching fish with specific gear).

5) *Social infrastructure* (SI) includes the web of relationships among individuals that allow them to communicate and exchange information or materials (e.g. shared values among a community of fishers, heterogeneity of the community, levels of trust among fishers).

The remaining components of the CIS framework include two different types of actors: Resource users and public infrastructure providers. The *Resource users* (RUs) which include any appropriator of the resource within the system under study (e.g. small-scale, industrial, or recreational fishers, individuals involved in fish processing or gear mending, indigenous groups of people living in the region, tourists, etc.). The *Public infrastructure providers* (PIPs) are intimately related to the type of different *Public Infrastructures* (PI) they can provide. For example, PIPs can include individuals or groups of individuals such as government organizations tasked with the responsibilities of fisheries and/or conservation management activities who can provide legislation changes for the implementation and establishment of marine reserves as well as endorse the elaboration of management programs that will dictate how the reserve is to operate (SHMI). Non-profit organizations active in the region are another type of PIP that can provide infrastructure for carrying out management activities in the form of funding for hard human-made infrastructure (HHMI) (e.g. biological monitoring equipment, conditioned rooms for holding stakeholder meetings) or for soft human-made infrastructure (SHMI) (e.g. capacity building workshops for fishers engaged in conservation activities or for increasing fishers' capacities for leadership, management, and conflict resolution). Academic researchers can provide information and data to help marine reserve management (e.g. scientific articles supporting the need for marine reserves in an area or the current success of existing reserves, another example of SHMI). Groups of resource users can also act as PIPs when engaging in specific collective choice activities, which can also provide some level of social infrastructure (SI) (e.g. social networks of fishers engaged in specific similar activities).

The CIS framework emphasizes the importance of the characteristics of each type of infrastructure within a CIS, but it also highlights the relationships between the different groups of actors within a CIS and the infrastructures, as well as their relationship with outside disturbances or exogenous drivers (in previous instantiations of the CIS framework, these have been called links, now "spillovers"). These relationships represent the dynamic processes through which the different components of the CIS interact but that may be difficult to observe or predict (Anderies et al. 2016). In other words, the CIS framework spotlights the dynamic interactions between the exogenous variables identified in the IAD framework (i.e. the biophysical context, the actors, and the rules in use) that structure dynamically evolving action situations (Anderies and Janssen 2013). Furthermore, it more easily addresses issues related to unintended consequences (i.e. externalities) that come with any productive activity (Anderies 2015), thus incorporating important design elements for robust CISs.

Marine reserves occur within particular socioeconomic and historical contexts that limit what can be accomplished by using them as a tool for fisheries management. Human behavior is the focus of fisheries regulations as it is the resource users who are the agents of change and will be directly affected by the regulations (Jentoft et al. 2007). Therefore, marine reserves regulate people directly by restricting their access to designated areas (Fujitani et al. 2012). We can think of many components of an SES that might affect whether a marine reserve is successful or not (e.g. as size and connectivity of the reserve, the habitats and species it protects, fisher communities it affects, opportunity cost to fishers, cost of enforcement of fishing regulations, or the static (e.g. benthic) or mobile (e.g. migratory) nature of the resource itself). Because the CIS framework considers the natural, governance, and human components and their associated infrastructures as a coupled system, it can facilitate understanding of how all these issues affect effectiveness by highlighting how the different types of infrastructure are interacting with each other and with the actors in the system.

1.6 A hypothetical example of using the CIS framework in the context of marine reserves

To illustrate how the CIS framework can be applied to look at the components of a generic case of a marine reserve, I will follow earlier hypothetical example #2 in which a formal stakeholder committee with representatives from each sector come together to discuss and make decisions over a proposal to implement a marine reserve. In CIS terms, a typical system can include patches of coral reef NI where fish stocks provide resources to a set of small-scale fisher RUs from at least two communities (one next to the fishing grounds and one farther away) that, at the operational level, engage in the extraction of those resources for a living but also can endure losses when stocks decline (link 1). A marine reserves is thus a management tool with specific spatial and temporal restrictions that are described through public SHMI produced by PIPs (through link 3) with the goal of influencing how the RUs interact with the resource (through link 5). In some cases, RUs can interact with PIPs (through link 2) by requesting changes to PIPs, influencing decisions, or even becoming PIPs themselves to participate within action situations taking place at the collective and constitutional choice levels.

The formation of a stakeholder committee would include PIPs that are representatives from all the relevant sectors that would be potentially impacted by the presence of a marine reserve (e.g. fisher RUs), or that are in a position where they can contribute to the discussion (e.g. academics, non-profit organizations), or enable future decisions to become actionable outcomes (e.g. government officials). This committee could then draft a series of guidelines, recommendations, or even a plan of action with regards to how the implementation of the marine reserve should take place (i.e. building a piece of SHMI) by incorporating relevant sources of information provided by the various PIPs involved. For example, members of the committee can discuss declining stock trends as evidenced by both local knowledge from fishers (HI) and academics collecting census data. They can also discuss specifics on the marine reserve design such as formal objectives, size, location, duration of the closure (e.g. 10-15 years or permanent) and whether fishers from the nearby community will have exclusive fishing rights to adjacent areas. Furthermore, the dynamics of the action situations within which the stakeholder committee makes decisions could be influenced by the different levels of local knowledge, experience, leadership, and other abilities that members of the committee have (i.e. HI) as well as prior social relationships (either positive or negative) among participants who may or may not have worked together in the past (i.e. SI).

An important aspect of the marine reserve design might involve the identification of specific biophysical indicators that can help monitor the state of the resource within the marine reserve, such as the collection of fish census data (through link 4) to assess trends over the years (or before the reserve is established if PIPs express a need to establish a baseline before the reserve is implemented). This action would require the availability of specific HHMI such as scuba diving gear, vessels, and gas money, that can be provided and maintained by some of the PIPs (through link 3) to carry out biological monitoring activities. Furthermore, the continued participation of all members of the stakeholder committee within recurring meetings would have to be maintained to achieve effectively working action situations. Therefore, the relationships between committee participants (i.e. SI) would also have to be preserved in a positive way to ensure continued participation, thus requiring effective leaders and highly skilled individuals with good facilitating skills (i.e. HI) to spearhead the efforts. Once the marine reserve were established, RU compliance with the no-take regulations within the marine reserve would have to be monitored (via link 5) either by existing PI that is charged with the responsibility of patrolling and enforcing compliance within the natural systems (e.g. the coast guard or park rangers for the marine reserve) or by other institutions that are formed and agreed upon by local PIPs taking on the responsibility of monitoring for compliance.

The relationship between RUs and the PI (link 6) is of particular importance for marine reserve systems. While RUs can become PIPs by participating in these stakeholder meetings and engaging in the production of SHMI that dictates the specifics of the marine reserves (via link 3), they can also be involved in the process of implementation of the reserve in different ways without being directly involved in the decision-making process (via link 6). For instance, official legal guidelines (PI) to establish marine reserves (or unofficial ones established by the stakeholder committee) may call for a public hearing in which RUs are presented with the proposal and asked for their opinion. In this way, RUs are part of the coproduction of infrastructure, and whether these opinions are incorporated into the proposal would be decided on the guidelines that were followed. Another example of coproduction of infrastructure is when the guidelines for designing the marine reserve call for a participative mapping process in which a large number of RUs are asked to design their ideal zonation for the marine reserve proposal.

Once a marine reserve is established, it becomes imperative that all RUs within the CIS become aware of the location of the marine reserve, the restrictions it holds, and the sanctions of not complying with the regulations. This information is also provided to the RUs via link 6 as it is intended to educate the RUs and aid with the monitoring and sanctioning mechanisms. Finally, unofficial norms (PI) previously established among the RU fishers of the communities affected might be of help when mediating conflicts that arise between RUs and related to the presence of the marine reserve. These unofficial norms often occur within actions situations where organized RUs exhibiting cooperative behavior and are willing to reach certain agreements that are likely to benefit all. This kind of conviction is likely useful when expecting RU compliance with marine reserve regulations, especially if they were heavily involved in the process and supported the initiative. Therefore, it would be important to consider these norms during the discussions at the committee meetings.

The final components of the CIS framework to describe in the context of a stakeholder committee deciding on the implementation of a marine reserve are the include exogenous drivers. These factors can influence the NI itself, such as natural phenomena like hurricanes disturbing the sediment flow rate within the potential marine reserve, or climate change-induced thermal anomalies affecting the patches coral reef habitat within the reserve area, further affecting the fishery resources within. On the other hand, there can be exogenous drives related to major changes in the political system, such as the signing of an important international agreement calling adhering nations to increase the area within national waters under the protection of marine reserves by a specific year. International agreements like these can thus re-shape action situations at the constitutional level by having an impact on the way in which PIPs operate to proceed with the establishment of the marine reserve (e.g. the process may have to be accelerated to meet the treaty's demand to the point which it excludes certain guidelines that called for a more RU-inclusive process). The same type of CIS analysis could be carried out for hypothetical examples 1 and 3, or all three examples could be considered as co-occurring under different time scales and analyzed at the different levels of analysis.

1.7 Conclusions

Understanding the barriers to marine reserve efficacy through the lens of the CIS framework allows identification of both the components of a system and the interactions between linked action situations that structure dynamic change within the CIS. In other words, we can more easily identify weaknesses within the system and understand what infrastructures (or combinations of infrastructures) can be influenced (or need to change) to increase effectiveness of marine reserves in a way that the CIS is robust to challenges from outside the system and capable of delivering benefits for both nature and people. While other existing frameworks applied to addressing marine reserve governance issues consider the application of institutional analysis and concepts from the common pool resource literature being of little use to address practical operational mechanisms by which recommendations can be effectively applied to solve governance problems of marine reserve, the CIS framework provides a new way to understand the governing dynamics of marine reserve systems. The CIS framework can be applied to marine reserve contexts of multiple spatial and institutional scales of analysis (i.e. addressing spatial and human connectivity as well as multiple levels of institutional structures).

This chapter has explored looking at marine reserves from a CIS perspective to better understand the interdependencies occurring between social, economic, natural, and institutional processes affecting marine reserve outcomes. I have highlighted attributes that make marine reserve systems a good study subject from a CIS perspective, and this type of studies can be extended to formal appraisal of the probability of success of a reserve system from a systematic analysis of existing case studies. I recommend both conservation and fisheries management scientists consider adopting the concepts of infrastructure and Coupled Infrastructure Systems as units of analysis for understanding problems associated with governing shared fishery resources through marine reserves and their effectiveness at solving overexploitation problems. Future applications of CIS analysis to marine reserve problems will provide a powerful mechanism to synthesize the existing body of work surrounding marine reserve efficacy and contribute towards better understanding the role of context influencing successful outcomes for marine reserves.

1.8 References

Agardy, T., P. Bridgewater, M. P. Crosby, J. Day, P. K. Dayton, R. Kenchington, D. Laffoley, P. McConney, P. A. Murray, J. E. Parks, and L. Peau. 2003. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation: Marine and freshwater ecosystems **13**:353-367.

Agrawal, A. 2003. Sustainable governance of common-pool resources: context, methods, and politics. Annual Review of Anthropology **32**:243-262.

Anderies, J. M. 2015. Understanding the Dynamics of Sustainable Social-Ecological Systems: Human Behavior, Institutions, and Regulatory Feedback Networks Bulletin of Mathematical Biology **77**:259-280.

Anderies, J. M., and M. A. Janssen. 2013. Robustness of Social-Ecological-Systems: Implications for public policy Policy Studies Journal **41**:513-536.

Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. A framework to analyse the robustness of Social-Ecological-Systems from an institutional perspective. Ecology and Society **9**:18.

Anderies, J. M., M. A. Janssen, and E. Schlager. 2016. Institutions and the performance of coupled infrastructure systems. International Journal of the Commons **10**:495 - 516.

Arias, A., J. E. Cinner, R. E. Jones, and R. L. Pressey. 2015. Levels and drivers of fishers' compliance with marine protected areas. Ecology and Society **20**:19.

Arias, A., and S. Sutton. 2013. Understanding Recreational Fishers' Compliance with No-take Zones in the Great Barrier Reef Marine Park. Ecology and Society **18**:18.

Aswani, S., and P. Weiant. 2004. Scientific evaluation in women's participatory management: monitoring marine invertebrate refugia in the Solomon Islands. Human Organization **63**:301-319.

Basurto, X., and E. Coleman. 2010. Institutional and ecological interplay for successful self-governance of community-based fisheries. Ecological Economics **69**:1094-1103.

Becker, C. D., and E. Ostrom. 1995. Human ecology and resource sustainability: the importance of institutional diversity. Annual Review of Ecology and Systematics **26**:113-133.

Bennett, N. J., and P. Dearden. 2014a. From measuring outcomes to providing inputs: governance, management, and local development for more effective marine protected areas. Marine Policy **50**:96 - 110.

Bennett, N. J., and P. Dearden. 2014b. Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. Marine Policy **44**:107 - 116.

Bergseth, B., J. Cinner, and G. Russ. 2015. Measuring and monitoring compliance in no-take marine reserves. Fish and Fisheries **16**:240-258.

Berkes, F., and C. Folke. 1998. Linking Social and Ecological Systems for Resilience and Sustainability. Pages 1–25 *in* F. Berkes and C. Folke, editors. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge Univerisity Press, Cambridge, UK.

Charles, A., and L. Wilson. 2009. Human dimensions of marine protected areas. ICES Journal of Marine Science **66**:6-15.

Cinner, J., T. M. Daw, C. Huchery, P. Thoya, A. Wamukota, M. Cedras, and C. Abunge. 2014. Winners and losers in marine conservation: Fisher's experiences of displacement and perceptions of spillover from marine protected areas in Seychelles and Kenya. Society & Natural Resources **27**:994-1005.

Cinner, J. E. 2005. Socioeconomic factors influencing customary marine tenure in the Indo-Pacific. Ecology and Society **10**:36.

Cinner, J. E. 2007. Designing marine reserves to reflect local socioeconomic conditions: lessons from long-enduring customary management systems. Coral Reefs **26**:1035-1045.

Cinner, J. E., M. J. Marnane, and T. R. McClanahan. 2005. Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. Conservation Biology **19**:1714-1723.

Colding, J., and C. Folke. 2001. Social taboos: "Invisible" systems of local resource management and biological conservation. Ecological Applications **11**:584-600.

Crawford, B. R., A. Siahainenia, C. Rotinsulu, and A. Sukmara. 2004. Compliance and enforcement of community-based coastal resource management regulations in North Sulawesi, Indonesia. Coastal Management **32**:39-50.

Fernandes, L., J. Day, B. Kerrigan, D. Breen, G. De'Ath, B. Mapstone, R. Coles, T. Done, H. Marsh, I. Poiner, T. Ward, D. Williams, and R. Kenchington. 2009. A process to design a network of marine no-take areas: Lessons from the Great Barrier Reef. Ocean and Coastal Management **52**:439-447.

Fernandes, L., J. Day, A. Lewis, S. Slegers, B. Kerrigan, D. Breen, D. Cameron, B. Jago, J. Hall, D. Lowe, J. Innes, J. Tanzer, V. Chadwick, L. Thompson, K. Gorman, M. Simmons, B. Barnett, K. Sampson, G. De'Ath, B. Mapstone, H. Marsh, H. Possingham, I. Ball, T. Ward, K. Dobbs, J. Aumend, D. Slater, and K. Stapleton. 2005. Establishing representative no-take areas in the Great Barrier Reef: Large-scale implementation of theory on marine protected areas. Conservation Biology **19**:1733-1744.

Fernberg, P., J. E. Caselle, J. Claudet, M. Clemence, S. D. Gaines, J. A. Garcia-Charton, E. J. Goncalvez, K. Grorud-Colvert, P. Guidetti, S. R. Jenkins, P. J. S. Jones, S. E. Lester, R. McAllen, E. Moland, P. S., and T. K. Sorensen. 2012. The science of European marine reserves: Status, efficacy, and future needs. Marine Policy **36**:1012-1021.

Fraschetti, A., J. Claudet, and K. Grorud-Colvert. 2011. Management - Transitioning from single-sector management to ecosystem-based management: What can marine protected areas offer?*in* J. Claudet, editor. Marine Protected Areas, A Multidisciplinary Approach. Cambridge University Press, New York, USA.

Fujitani, M. L., E. P. Fenichel, J. Torre, and L. R. Gerber. 2012. Implementation of a marine reserve has a rapid but short-lived effect on recreational angler use. Ecological Applications **22**:597-605.

Green, A. L., L. Fernandes, G. Almany, R. Abesamis, E. McLeod, P. M. Aliño, A. T. White, R. Salm, J. Tanzer, and R. L. Pressey. 2014. Designing Marine Reserves for Fisheries Management, Biodiversity Conservation, and Climate Change Adaptation. Coastal Management

42:143-159.

Gurney, G., J. E. Cinner, J. Sartin, R. L. Pressey, N. C. Ban, N. Marshall, and D. Prabuning. 2006. Participation in devolved commons management: Multiscale socioeconomic factors related to individuals' participation in community-based management of marine protected areas in Indonesia Environmental Science and Policy **61**:212-220.

Gurney, G., R. L. Pressey, J. E. Cinner, R. Pollnac, and S. Campbell. 2015. Integrating Conservation and Development: evaluating a community-based marine protected area project for equity of socioeconomic impacts. Philosophical Transactions of the Royal Society B:20140277.

Jentoft, S., T. C. van Son, and M. Bjørkan. 2007. Marine protected areas: a governance system analysis. Human Ecology **35**:611-622.

Jones, P. J. S. 2014. Governing Marine Protected Areas: Resilience through diversity. Routledge, Oxon, UK.

Kareiva, P. 2006. Conservation Biology: Beyond Marine Protected Areas. Current Biology **16**:R533-R535.

Kiser, L. L., and E. Ostrom. 1982. The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches. Pages 179–222 *in* E. Ostrom, editor. Strategies of Political Inquiry. Sage, Beverly Hills, CA.

McClanahan, T. R., M. J. Marnane, J. E. Cinner, and W. E. Kiene. 2006. A comparison of marine protected areas and alternative approaches to coral-reef management. Current Biology **16**:1408-1413.

McGinnis, M. D. 2011. An introduction to IAD and the langauge of the Ostrom Workshop: A simple guide to a complex framework. Policy Studies Journal **39**:169 - 183.

Ostrom, E. 1990. Governing the commons: The evolution of institutions for collective action. Cambridge University Press, Cambridge.

Ostrom, E. 2005. Understanding Institutional Diversity. Princeton University Press, Princeton, NJ.

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas.

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science **325**:419-422.

Ostrom, E. 2011. Background on the Institutional Analysis and Development Framework. Policy Studies Journal **39**:7-27.

Ostrom, E., R. Gardner, and J. Walker. 1994. Rules, Games, and Common-Pool Resources. University of Michigan Press, Ann Arbor, MI, USA.

Pollnac, R., P. Christie, J. E. Cinner, T. Dalton, T. M. Daw, G. E. Forrester, N. A. J. Graham, and T. R. McClanahan. 2010. Marine reserves as linked social-ecological systems. Proceedings of the National Academy of Sciences **107**:18262-18265.

Saarman, E., M. Gleason, J. Ugoretz, S. Airamé, M. Carr, E. Fox, A. Frimodig, T. Mason, and J. Vasques. 2013. The role of science in supporting marine protected area network planning and design in California. Ocean and Coastal Management **74**:45-56.

Sanchirico, J. N., D. Holland, K. Quigley, and M. Fina. 2006. Catch-quota balancing in multispecies individual fishing quotas. Marine Policy **30**:767-785.

Sanchirico, J. N., and J. E. Wilen. 2001. A bioeconomic model of marine reserve creation. Journal of Environmental Economics and Management **42**:257-276.

Smith, M. D., J. Lynham, J. N. Sanchirico, and J. A. Wilson. 2010. Political economy of marine reserves: Understanding the role of opportunity costs. Proceedings of the National Academy of Sciences **107**:18300-18305.

Smith, M. D., and J. E. Wilen. 2003. Economic impacts of marine reserves: the importance of spatial behavior. Journal of Environmental Economics and Management **46**:183 - 206.

Smith, M. D., and J. E. Wilen. 2004. Marine reserves with endogenous ports: empirical bioeconomics of the California sea urchin fishery. Marine Resource Economics **18**:85 - 112.

Spalding, M., I. Meliane, N. J. Bennett, P. Dearden, G. Pawan, P. G. Patil, and R. D. Brumbaugh. 2016. Building towards the marine conservation end-game: consolidating the role of MPAs in a future ocean. Aquatic Conservation: Marine and freshwater ecosystems **26**:185 - 199.

Weigel, J. Y., K. O. Mannle, N. J. Bennett, E. Carter, L. Westlund, V. Burgener, Z. Hoffman, A. S. Da Silva, E. A. Kane, J. Sanders, C. Piante, S. Wagiman, and A. Hellman. 2014. Marine protected areas and fishers: Bridging the divide. Aquatic Conservation: Marine and freshwater ecosystems **24**:199 - 215.

CHAPTER 2

GOVERNANCE OF NO-TAKE AREAS FOR FISHERIES MANAGEMENT: LESSONS LEARNED FROM THE GULF OF CALIFORNIA, MEXICO

2.1 Introduction

In the face of increasing anthropogenic threats to marine systems, marine protected areas (MPAs), specifically no-take areas (NTAs), have become a popular tool to promote sustainable fisheries management and protect marine biodiversity. There is a huge diversity of NTA designs and strategies currently being implemented worldwide that vary that vary with respect to the type of NTA, the goals and objectives pursued, the biophysical design criteria, and the geographical, cultural, social and economic context within which it is implemented. Even NTAs within the same national jurisdiction and operating under the same legal systems but under different governance and institutional contexts have met various levels of success at achieving their objectives. In many cases, limited success of certain NTAs can be attributed to the lack of attention to stakeholder interests and human capacity building (Gill et al. 2017), as well as the socio-economic (McClanahan 1999, Christie et al. 2003, Christie 2004, Cinner 2007) and institutional (Bernstein et al. 2004) contexts within which NTAs are established.

Given the diversity of NTA design and management strategies, as well as the wide variation in contextual factors that have an impact on the effectiveness of NTAs, no single model for NTAs can fit all circumstances and be universally applicable (Agardy et al. 2003). Multiple efforts have begun to explore methods through which the human dimensions of NTAs can be incorporated into the planning and implementation processes of NTAs, ranging from the consideration of incentives driving fisher behavior and their response to NTAs, social context, community-based management, compliance, fisher perceptions, and social inequity within small-scale studies, as well as large-scale studies and new frameworks to analyze the governance of marine protected areas (see Chapter 1 for a summary on these efforts). Focusing attention solely on governance, however, without entirely considering the ecological, social, economic, and institutional system in which a set of NTAs is embedded can be misleading (Anderies et al. 2016).

I apply the Coupled Infrastructure Systems (CIS) (Anderies et al. 2016) framework to provide a conceptual roadmap for identifying the contrasting approaches to implement effective NTAs in the GOC region and their likelihood to facilitate (or hinder) NTA implementation outcomes as well as effective performance. In this chapter, I examine the socioeconomic, ecological, and institutional contexts of NTAs in the GOC from a CIS perspective. I collected extensive empirical data on trajectories of NTAs in the GOC from expert and key stakeholder representatives over one year at the regional scale of the GOC spatial scale. I use these data to describe a qualitative case study research methodology to appraise the use NTAs in the systems in the which they are embedded. I focus on the region of the Gulf of California (GOC), Mexico, to illustrate the different trajectories that existing NTAs in this region have followed. More specifically, I address three salient research questions: 1) What are the key factors that influence implementation and performance outcomes of NTAs in the GOC? 2) To what extent do feedbacks within the different components of an NTA CIS affect the two types of outcomes? 3) What are the implications for the policy structures that govern the implementation and operation of NTAs in Mexico?

2.2 Methods

2.2.1 Conceptual framework for CIS analysis

The CIS framework (Figure 2.1) is an extension of the well-known IAD framework among common-pool-resource (CPR) scholars (Ostrom 2005). The IAD has been used in the context of Mexican institutions to understand access regulation and resource use of small-scale fisheries in villages operating in the GOC (Cinti et al. 2010a, Cinti et al. 2014). Another IAD extension, commonly known as the SES framework (Ostrom 2007, 2009), has been applied to identify regions in the GOC that exhibit greater potential for contributing to sustainable resource use and management within a multiple locality, spatially explicit setting (Leslie et al. 2015). Following (Anderies et al. 2016), I adopt the concept of *infrastructures* to describe multiple sets of coherent structures (that can provide potential outcomes accessible to humans) present within a system (i.e. a Coupled Infrastructure System, or CIS).

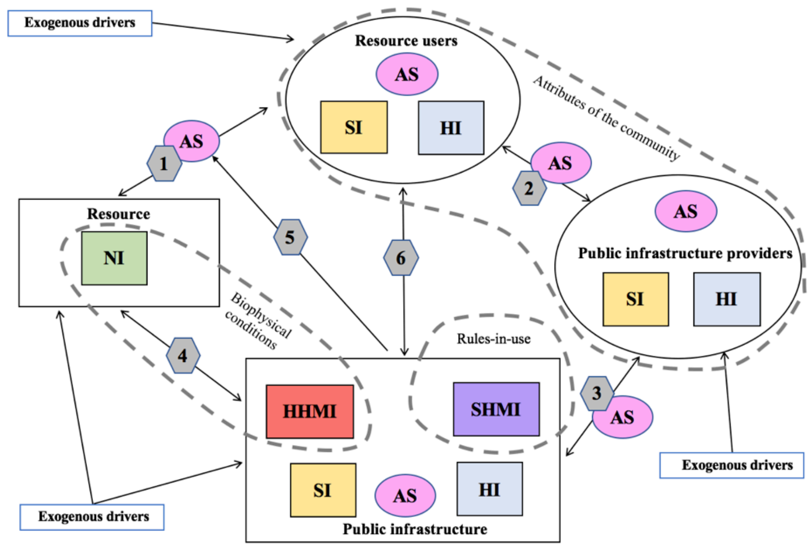

Figure 2.1. The Coupled Infrastructure Systems (CIS) framework, adapted from (Anderies et al. 2016). AS = Action situation, NI = Natural infrastructure, SI = Social infrastructure, HI = Human infrastructure, HHMI = Hard human-made infrastructure, SHMI = Soft human-made infrastructure. Hexagons indicate links between the CIS components, numbered for identification purposes only.

The types of infrastructures include: *Natural* (NI) (e.g. the resource, ecological, and biophysical components of a system, within which lies a core component of the CIS framework known as "Resource"), *Hard human-made infrastructure* (HHMI) (e.g. includes human-made structures), *Soft human-made infrastructure* (SHMI) (e.g. guidelines for using other types of infrastructures), *Human infrastructure* (HI) (e.g. knowledge, levels of experience, and capacities of a particular group of people or community), and *Social infrastructure* (SI) (e.g. web of relationships among individuals that allow them to exchange materials and information). The remaining components of the CIS framework include two sets of actors: *Resource users* (RUs) and *Public*

Infrastructure Providers (PIPs), both interacting separately with a given set of *Public Infrastructures* (PI). Finally, the CIS framework highlights the connections (or links) between the different groups of actors within a CIS and the associated infrastructures, as well as their relationship with outside disturbances or exogenous drivers. These links thus represent the dynamic processes through which the different components of the CIS interact.

2.2.2 Qualitative case study analysis through a CIS lens

I implemented a qualitative case study analysis following an embedded multiple-case design approach (Yin 2014) including seven individual cases of NTA implementation efforts throughout the GOC (Table 2.1). I individually analyzed each case study through a CIS lens where all components, their associated infrastructures, and their interactions were characterized for subsequent cross-case comparison and contrasting pattern matching with respect to a set of fourteen theoretical propositions developed prior to the study. These theoretical propositions are associated with how key variables (all within the different components and links of the CIS framework) are potentially related to the difficulties of implementing NTAs and their subsequent performance (Table 2.2).

Table 2.1. General characteristics of the seven NTA cases. FRZ = Fishing Refuge Zone. ARPEA = Refuge Area to Protect Aquatic Species.

Case ID	*Name*	*# of individual NTAs*	*Year decreed*	*MP publication*	*NTA (km^2) / % of MPA*
* RB-AGCDRC	Alto Golfo de California y Delta del Río Colorado	1 Core zone 1 ARPEA 2-year gillnet ban zone	1993 2005 2015	1996 2005 NA	2,552.94 / 45% 1,263.85 / 80% > 5,000
* PN-CP	Cabo Pulmo	3 Core zones	1995	2006	24.76 / 35%
* RB-ISPM	Isla San Pedro Mártir	1 Core zone	2002	2011	8.21 / 2.7%
PN-AES	Archipielago Espiritu Santo	3 Core zones	2007	2015	486.55
RB-BACBS	Bahía de los Ángeles, Canal de Ballenas y Salsipuedes	6 Core zones	2007	2014	2.07 / 0.05%
* FRZ-San Cosme	Corredor San Cosme-Punta Coyote	1 FRZ	2007	NA	3,879.57
FRZ-CB	Cerro Bola	11 FRZs	pending	NA	

Table 2.2. Theoretical propositions relevant for Implementation (I), Performance (P), or Both (B) outcomes and their respective CIS components.

Outcome	Theoretical propositions	CIS component
P	1. Biophysical / ecological processes influencing implementation, zonation, or performance	NI
B	2. Attributes of the community (e.g. abilities, capacities, levels of experience, skills) influencing NTA implementation and/or performance.	HI
B	3. Human-made (hard/soft) infrastructure influencing the implementation process and subsequent NTA performance	HHMI SHMI
B	4. Community-established unofficial norms demonstrating cooperative behavior among influencing compliance and support for NTAs	SHMI
B	5. Participation of PIPs playing an role in facilitating implementation and/or performance	PIPs through Link 3
B	6. NTA implementation efforts differing between bottom-up, top-down, and combination initiatives	PI
B	7. Official legal procedure and guidelines through which NTAs are implemented and made operational	Link 3/PI
B	8. High levels of community involvement... a. During the early stages of NTA implementation process b. After the NTA has been implemented c. Specifically for compliance monitoring of NTA regulations	a/b. Links 6 or 3 c. Link 5
I	9. Initial support/opposition towards NTA implementation from the different stakeholder groups	Link 6
B	10. Information available to RUs	
P	11. RUs implementing social sanctions towards non-complying individuals	
P	12. Other economic activities taking place in NI	Link 1
I	13. Exogenous drivers influencing the decisions made by PIPs with respect to NTA implementation processes	Exogenous drivers
P	14. Exogenous drivers affecting the natural infrastructure where NTAs are located	Exogenous drivers

I identified two different types of outcomes to differentiate between factors that affect the implementation process of the NTA and those that are likely to affect the performance of the NTA. This also helps differentiate between temporal scales when looking at the status of a NTA-CIS prior to the implementation of the NTA as well as during its subsequent performance after implementation. The theoretical propositions represent the differences I expected to find among the case studies, characterized by whether they were related to implementation or performance outcomes of NTAs. Given the nature of this chapter and the methodology employed, formal evaluations of successful and non-successful outcomes were not explicitly carried out. However, three criteria were taken into consideration when assessing whether experts perceived individual variables were as related to potentially successful outcomes: 1) the objectives of the NTA being met (relevant to both implementation and performance), 2) resource users not over-appropriating the fishery resources (relevant to performance), and 3) there are no critical conflicts between the actors due to the prospect (or presence) of the NTA (relevant to both implementation and performance).

Each case study was intentionally selected in anticipation of obtaining contrasting results for anticipatable reasons (based on a literature search and expert opinion). Information on the different components CIS framework was collected through multiple sources including structured interviews among different key experts and primary and gray literature related to each single case study (e.g. reports, formal studies or evaluations of each case study, scientific publications, administrative documents including management programs and federal decrees, etc.). The interview process with key informants and local experts was carried out either in-person or via phone (Skype) call. The response ratio for interviewees was 54%, with 27 interviews carried out. For each case study, experts interviewed included at least one representative from each of the academic, non-profit, and the appropriate government agency sectors, when possible. Experts were carefully selected to include individuals recognized for having years of knowledge and experience within their sector and with the processes for implementing the NTAs in each case study. They were asked a set of thirty structured questions based on their own experience with the case study.

2.2.3 Study area

The GOC includes 375,000 km^2 of semi-enclosed sea bounded by the states of Baja California, Baja California Sur, Sonora, Sinaloa, and Nayarit in northwestern Mexico. In 2005, it became a UNESCO World Heritage Site due to its high levels of biodiversity, productivity, striking landscapes, and unique oceanographic processes (Carvajal et al. 2010). Given the high rate of primary productivity supporting complex food webs, the complex topography and oceanography enabling habitat diversity, and the warm and calm waters during the winter and spring, the Gulf harbors 80% of the marine mammals in Mexico (Niño-Torres et al. 2011), five of the seven sea turtle species (Seminoff 2010), over 4,900 invertebrate (Brusca and Hendrickx 2010) and over 900 fish (Brusca et al. 2005) species (with nearly 10% being endemic to the GOC (Hastings et al. 2010) and over 80 importantly commercial species (Moreno-Báez et al. 2012)). The GOC currently has eight decreed MPA-type instruments of various categories and under different jurisdictions (explained below) (Figure 2.2).

Economic activities include fisheries and tourism, with a growing aquaculture industry. Fisheries are the most important economic activity with 52% of Mexico's fishery-related jobs are concentrated in the region (IMCO 2013). The main fisheries sectors are artisanal (small-scale fishers, SSFs), industrial, sport (recreational), and subsistence fishing (Cisneros-Mata 2010). SSFs work with hand-operated gear such as gill nets, hook and line, hand fishing line, traps, and longlines, that they use in small 6-8m long small skiffs (pangas) made of fiberglass with outboard gasoline motors (55 –

150 hp) (Cisneros-Mata 2010). Industrial fishermen operate on diesel-run industrial vessels of ~15 metric ton capacity that can operate more mechanized gear such as purse seine nets, trawl nets (paired, bottom, and midwater), long lines, and gill nets. They generally target 6 main species guilds (Cisneros-Mata 2010).

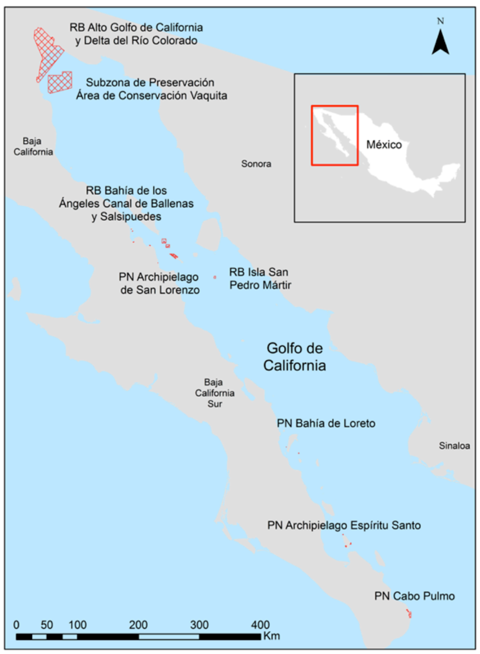

Figure 2.2. Existing NTAs in the Gulf of California, Mexico, including two NTA-type instruments established within the Mexican legal system: Natural protected areas (*left*) and Fishing refuge zones (*right*).

2.2.4 Formal Public Infrastructure for environmental protection and resource management

Environmental law (PI) guiding conservation and biodiversity management activities in Mexico is housed within the General Law of Ecological Balance and

Environmental Protection *(Ley General del Equilibrio Ecológico y Protección al Ambiente,* LGEEPA) (DOF 1988). Fisheries management law has a longer history, with initial guidelines decreed in 1925 defining fishing permits as the main management policy for harvesting marine species (Soberanes Fernández 1994), rebranded in 2000 as the General Law of Sustainable Fishing and Aquaculture (*Ley General de Pesca y Acuacultura Sustentable,* LGPAS), and introducing decentralization of management and administration of fisheries 2007 (DOF 2007) to allow states and municipalities to have participation in decision making and introduce new fisheries management tools (Cinti et al. 2010a), such as Fishing Refuge Zones (explained below). As such, the LGPAS provides the constitutional provisions to regulate, promote, and administer the use of fisheries and aquaculture resources within the national territory and areas under Mexican jurisdiction. Finally, the General Law of Wildlife Species (*Ley General de Vida Silvestre*, LGVS) coordinates the concurrence of federal, state, and municipal governments when taking actions related to the conservation and sustainable exploitation of wildlife species and their habitat within Mexican territory (DOF 2000b).

Multiple government organizations (authorities) that act as PIPs to establish and maintain legal procedures for the implementation and performance of NTAs in Mexico. All environmental authorities are housed within the Secretariat of the Environment and Natural Resources (*Secretaria del Medio Ambiente y Recursos Naturales,* SEMARNAT) in charge of the protection, conservation, and harvesting of natural resources, as well as the development of environmental policy for sustainable development. SEMARNAT houses three important PIPs: 1) the National Commission of Natural Protected Areas (*Comisión Nacional de Áreas Naturales Protegidas,* CONANP), 2) the Federal Agency for the Protection of the Environment (*Procuraduría Federal para la Protección del Ambiente,* PROFEPA), and 3) the General Division of Wildlife Species (*Divisón General de Vida Silvestre*, DGVS).

CONANP is the main PIP in charge of formally proposing and managing natural protected areas. CONANP also houses the Conservation Program for Sustainable Development (*Programa de Conservación para el Desarrollo Sostenible*, PROCODES), which seeks to promote the conservation of ecosystems and their biodiversity within priority regions through sustainable use, equal opportunity for men and women, and emphasizing local indigenous populations. DGVS is in charge of regulating the use of species listed under special protection by Mexican bylaws. PROFEPA is the main administrative agency in charge of monitoring compliance of environmental protection regulations and enforcing and sanctioning those who infringe on these regulations. CONANP and DGVS coordinate with PROFEPA with respect to natural protected areas and species under special protection, respectively. In the same way, PROFEPA supports CONAPESCA (described below) for fisheries regulations. PROFEPA officials can be solicited for enforcement support by community members, CONANP, CONAPESCA, or the Mexican Navy (SEMAR) (which also provides enforcement support to PROFEPA when requested).

All fisheries management authorities are housed within the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (*Secretaria de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentación,* SAGARPA) in charge of promoting commercial fisheries, among other things. Crucial to their operation are its objectives of integrating fishing activities within the production chain of Mexico's economy, stimulating collaboration within the production sectors, and creating employment opportunities conducive to the strengthening of production activities. SAGARPA houses two important PIPs: 1) the National Commission for Fisheries and Aquaculture (*Comisión Nacional de Pesca y Acuacultura*, CONAPESCA), and 2) the National Institute of Fisheries (*Institutio Nacional de Pesca,* INAPESCA). CONAPESCA is the main federal organization in charge of designing, implementing, and enforcing fisheries policy regulations specified within the LGPAS, and they mainly operate by issuing and managing fishing permits or concessions. INAPESCA is generally known as a federal research institution responsible for providing scientific and technical advice for the development of fishing regulations.

2.2.5 NTAs as fisheries management tools within the Mexican context

An explicit regulation to design, establish, monitor and evaluate NTAs as a whole unit has not been created within the Mexican legislation (CEMDA and COBI 2010). Therefore, fisheries and environmental laws for land protected areas are commonly used to extend protection to the marine environment. Multiple tools within both the conservation and environmental protection legislation realm (housed within the LGEEPA) and the fisheries legislation realm (housed within the LGPAS) can thus be considered to function as NTAs (Figure 2.3). This chapter focuses on three of these management tools: *Natural Protected Areas* (NPAs), *Fisheries Refuge Zones* (FRZ), and *Refuge Areas to Protect Aquatic Species* (ARPEASs).

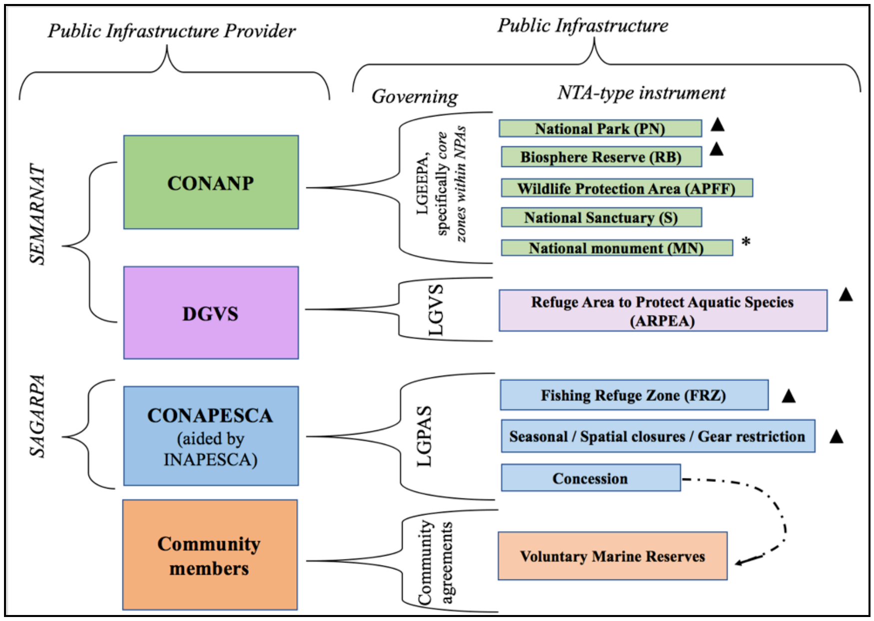

Figure 2.3. Instruments working as NTAs within the Mexican context. Dotted arrow indicates the potential of a concession to become a voluntary marine reserve. Symbols: ▲ = types explored within this study, * = not applied yet in the GOC.

The formal implementation of NPAs follows a well-drafted procedure described in the LGEEPA (DOF 1988) (Figure 1C, Appendix C). Some of the key elements of this procedure involve the elaboration of: 1) a *Prior Justification Study* (EPJ) that compiles all relevant technical and scientific biological and socioeconomic information needed to justify decree of the NPA, and 2) a *Management program* (MP), the main instruments used for planning, organizing, and coordinating management actions that are necessary for achieving the NPA's objectives (which are often aided by the EPJ). MPs are technically required to be published a year after the NPA's decree and evaluated every five years, though this does not often occur in practice for multiple reasons as evidenced by the case studies presented here. The LGEEPA also provides a scheme of different zonation possibilities for each NPA, including no-take areas (called *Core zones*) with the highest levels of protection by prohibiting harvest of its resources. Core zones can be surrounded by buffer zones where harvesting is allowed with certain restrictions on gear, season, or preferential fishing rights to nearby communities (as established within the NPA's MP).

There are several different categories of NPAs, though only four of these have been implemented within the marine territory of the GOC and only two of these are explored in the case studies presented here: *Biosphere reserves* (RB) and *National Parks* (PN). The main difference between RB and PN is with respect to the *buffer zones*. Preferential harvesting access is given to fishers legally ascribed to communities adjacent (or near) a RB, but not in the case of PNs. Finally, NPAs fall under CONANP's jurisdiction in terms of planning, designing, managing, and evaluating NPAs. However, enforcement for compliance with regulations within core zones falls under the jurisdiction of CONAPESCA (for fishing regulations, including no-take), PROFEPA, and SEMAR (at the request of CONANP's park rangers or PROFEPA).

The implementation of FRZs was initially suggested within the LGPAS in 2007, but it did not become formalized until 2014 (DOF 2014) (the case study FRZ-San Cosme illustrates the process that lead to their recognition). FRZs are administered by CONAPESCA as "areas within federal jurisdiction established with the main purpose of conserving and contributing, either naturally or artificially, to the development of the fishery resources within it...as well as preserving and protecting their surrounding environment" (LGPAS, Art. 4) (DOF 2007). FRZs can be established wherever there is a desire to support the development of fishery resources, including within NPAs (in which case the regulations from LGEEPA and LGVS also apply). FRZs can have four different types of zonation schemes, which indicate whether a specific area is totally closed to fishing (NTA) or partially (restricted fishing), as well as whether the closure is temporal (pre-defined) or permanent (until new amendments). CONAPESCA, with technical support from INAPESCA, can establish FRZs via the procedure shown in Figure 2C in Appendix C.

CONAPESCA, with support from INAPESCA, can also establish seasonal and spatial closures forbidding fishing activities for a specified period of time or in a specific zone, per species, geographical, temporal, or permanent zones, and with the purpose of safeguarding a particular species reproduction and recruitment processes (and in accordance to established official bylaws) (DOF 2007). However, there are no specific procedures or mechanisms for how they are determined or modified. Although species-specific seasonal closures have been established in the GOC, no official spatial closure of the NTA-type have been implemented by CONAPESCA besides FRZs, yet have great potential for the establishment of NTAs (CEMDA and COBI 2010).

Refuge Areas to Protect Aquatic Species (ARPEAs) seek the protection and conservation of native wildlife marine species (e.g. sea turtles, marine mammals, and endangered, threatened, or special protection species), as well as their habitats within federal jurisdiction (DOF 2000b). These areas fall under the jurisdiction of the General Division of Wildlife (DGVS) both for their implementation and subsequent management (Koch 2015). In case of overlap with a NPA, the ARPEA's protection program should be compatible with the NPA's general objectives and there should be coordination between CONANP and DGVS. The case study of RB-AGCDRC illustrates the use of this instrument and its consequences.

Voluntary Marine Reserves are areas with no legal backing within the Mexican environmental or fisheries legislation, and are thus subject to being managed by the fisher communities seeking their establishment. These areas are typically established via community agreements and maintained by particular fisher groups, cooperatives, or with the help of local non-profit organizations working in the area. Although not explicitly studied in this chapter, there have been cases within the GOC, as well as in the Mexican Pacific Northern coast, where fishers within a fishing cooperative who hold fishing concessions (i.e. exclusive fishing rights for a particular resource within a legally specified polygon and administered by CONAPESCA) become organized to design a *Voluntary Marine Reserve* within the polygons of their concession area, and to set it aside as a NTA for a period of time they themselves specify. In these cases, fishers from outside the cooperative (and not concession holders) can enter the area to fish other resources but not the resource specified in the concession. In this way, some concession areas can become voluntary marine reserves for specific species that are formalized through community agreements and operationalized by the concession holders themselves as NTAs (as illustrated in Figure 3). Some examples of these Voluntary Marine Reserves include the cases of El Rosario, Isla Magdalena, and Isla Natividad (Micheli et al. 2012, McCay et al. 2014).

2.3 Governance mismatches and delayed feedbacks

Understanding how individual components of a NTA-CIS system contribute to the NTA's effectiveness in both implementation and subsequent performance requires a diagnosis of the different types of infrastructures and action situations interplay during the different processes. In practice, the CIS framework is particularly helpful for understanding how these different components interact, what feedbacks are being generated, and how we can address changes needed to obtain effective outcomes. I present the results of a NTA-CIS analysis for all seven cases to illustrate key differences in four individual case studies (Figures 2.4 - 2.7).

2.3.1 Action situations influencing PI provision for NTA design and implementation

Across all case studies, complying with specific international agreements (e.g. CBD) was not a perceived as a motivation behind the implementation of NTAs within the Mexican context. Although ratified, many of these international treaties did not become officially part of the Mexican environmental legislation until 2013. Motivations for NTA implementation have historically arisen from the PIP sectors of federal government management agencies. Therefore, action situations taking place for the provision of guidelines and procedures of NTA establishment (i.e. in link 3) by organized PIP groups are extremely important for effective design and implementation.

In 1999 there was a push to increase protection to marine areas adjacent to islands of the GOC formally decreed as part of the *Área de Protección de Flora y Fauna Islas Golfo de California* (Wildlife Protection Area-Islands of the Gulf of California, APFF-IGC) (originally decreed in 1978 (DOF 1978) and later re-categorized as Wildlife Protection Area in 2000 (DOF 2000a)). The goal of these efforts was to extend the existing terrestrial conservation of the islands to their adjacent marine areas, thus achieving integral management of both terrestrial and marine ecosystems (CONANP-SEMARNAT 2007). Three main priority areas within the APFF-IGC were identified for their biological importance and feasibility for implementation of new marine NPAs.

These prioritizations led to the implementation of RB-ISPM (Figure 2.4), PN-AES, and the National Park Archipelago de San Lorenzo (not included in this study).

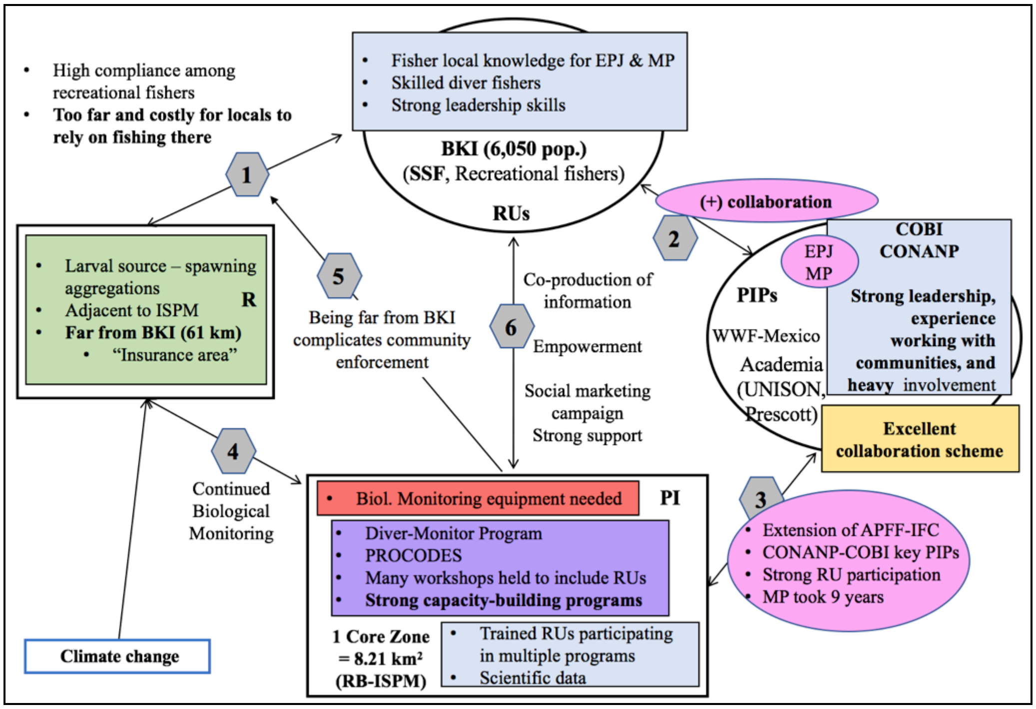

Figure 2.4. NTA-CIS for the Biosphere Reserve Isla San Pedro Mártir (RB-ISPM). BKI = Bahía de Kino; COBI = Comunidad y Biodiversidad.

In the most recent case presented here (ZRP-San Cosme), experts believe there was interest from non-profit organizations (e.g. NIPARAJA, COBI, FUNDEA) and federal management government agencies (e.g. CONAPESCA) to implement a new legal instrument for NTAs (FRZs) incorporated into LGPAS, and to produce a model where it could be tested for fisheries management (Figure 2.5). The presence of non-profit organizations working in the southern Baja California Sur region of the GOC (i.e. NIPARAJA doing community work in search for incentives to align conservation of reef areas with local fisher interests) led to its selection as a pilot project to implement the newer fishing regulations stated within the LGPAS in the form of a network of eleven FRZs that were heavily RU-inclusive (Espinosa-Romero et al. 2014). More importantly, it fueled the subsequent development of new SHMI in the form of an official bylaw detailing the legal standards, procedure, and guidelines for the implementation of future FRZs (DOF 2014).

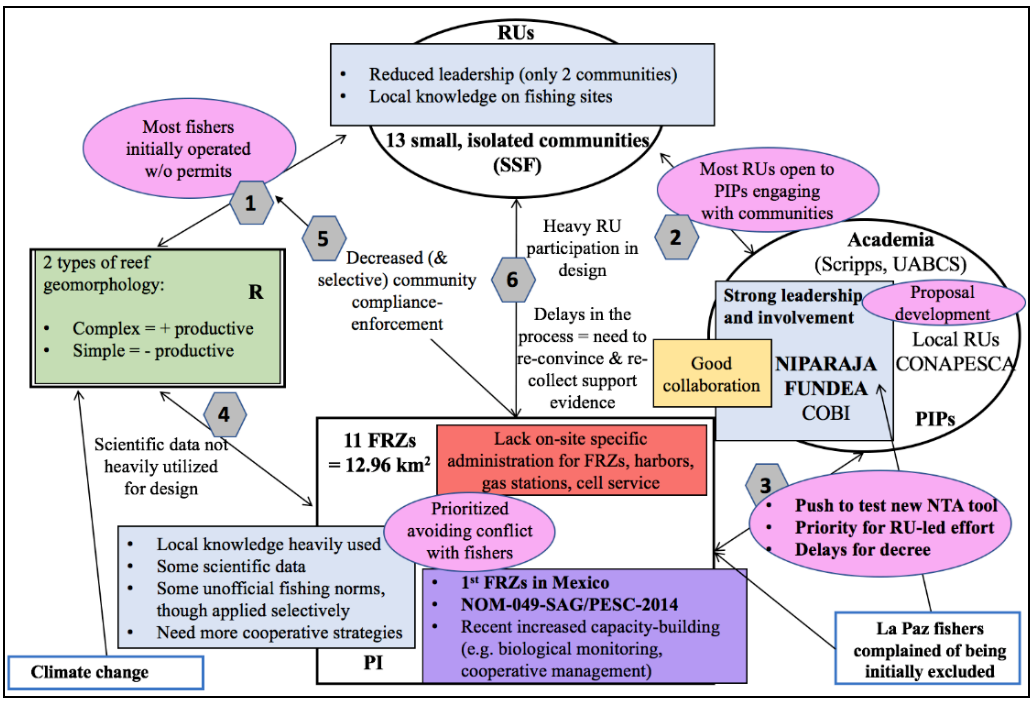

Figure 2.5. NTA-CIS for the Fishing Refuge Zone Corredor San Cosme-Punta Coyote (FRZ-San Cosme).

The RB-AGCDRC (Figure 2.6) is one of the oldest examples of NPA (and NTA) implementations in the GOC (CONANP-SEMARNAT 1995), but also one with the most recent and rushed additions (i.e. the 2005 decree of an ARPEA area for the vaquita recovery (DOF 2005), and the 2015 decree of a Temporal Exclusion Gillnet Zone (TEGZ) banning all gillnets for two years starting in 2015 (DOF 2015)). In this case study, three SHMIs have been decreed under clear official regulations but not properly implemented (rendering them highly ineffective) (Cisneros-Montemayor and Vincent 2016). Most of the motivation for these initiatives has come from the pressing concern for the endemic, critically endangered porpoise species: the vaquita (*Phocoena sinus*), currently estimated at populations below 100 individuals (CIRVA-5 2014). This case represents the strong shortcomings of PI implementation exclusively under the flagship species vision without considering the consequences for important fisheries sector operating in the region. A sole focus on charismatic species protection is perceived as distracting focus from the serious problem of illegal fishing and impunity (either through NTA non-compliance or gear regulations), "when in reality the vaquita decline is only a symptom of the larger problem" (pers. comm.). Furthermore, the short temporal nature of TEGZ has created the expectation among the fishers two years will determine whether gillnets are indeed causing vaquita declines. As recognized by the International Committee for the Recovery of the Vaquita (CIRVA), it is unreasonable that it can recover within such a short time frame.

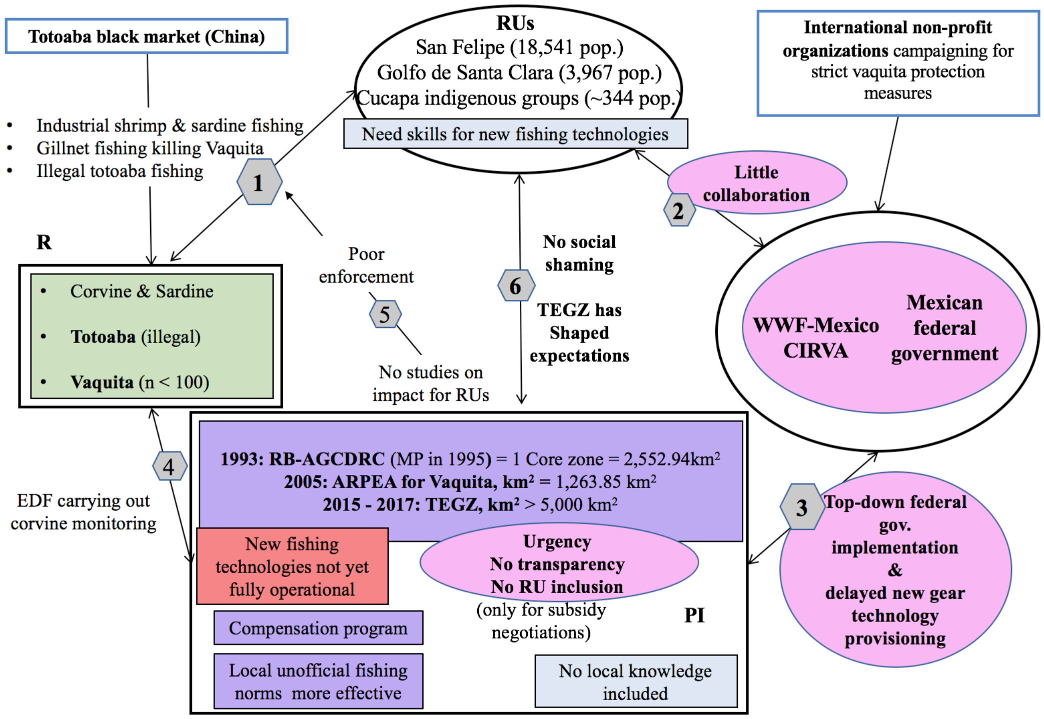

Figure 2.6. NTA-CIS for the Biosphere Reserve Alto Golfo de California y Delta Río Colorado (RB-AGCDRC).

Finally, the process of publishing a MP for a NPA to become formally operational is considered a bottleneck for all NPAs in Mexico for two main reasons: 1) massive amount of information required and effort to collect it, and 2) long bureaucratic procedure for its publication once the final document is ready for revisions. Even when most of the work to collect all the necessary information has been done during the elaboration of the EPJ, delays almost always occur. In the case of the RB-ISPM, the MPA was published almost ten years after the NPA was decreed (CONANP-SEMARNAT 2007). The process can easily get delayed during the multiple revision stages when it is subject to different interpretations by CONANP's federal authorities, as well as when political changes within the federal organizations re-start the revision process (Figure 1C in Appendix C). Similarly, the process to implement FRZs (Figure 2C in Appendix C) in the case of FRZ-San Cosme also had significant delays (e.g. efforts formally began in 2007, but it was not until 2012 when the FRZs were formally decreed) (a delay in link 3), and this was perceived to require further re-convincing for approval from local fishers to demonstrate their support for the initiative (leading to more work required to strengthen link 6).

Experts also perceive a general lack of public infrastructure provision (link 3) from reduced government agency staff and massive amount of work they are given responsibility of, which undermines their capacity to continuously monitor existing infrastructure and follow-through with on-going programs. The non-profit sector is perceived as more limited from a financial standpoint since the projects they carry out often depend on external funding.

2.3.2 The role of Human and Natural Infrastructures

Full incorporation of human capacity and local knowledge into the design and implementation processes of NTAs was not the norm back in the early 1990s when NTAs were beginning to be implemented in Mexico. Their design process rested solely on academics and the federal government without needing to include local representatives throughout the process. As evidenced by the most recent case studies presented here, there is an increasing trend towards heavily incorporating local RUs into the implementation processes. PIPs from government and non-profit sectors have begun to recognize the strong value of community involvement practices to achieve successful outcomes. In cases like RB-AGCDRC, these lessons have not been fully applied. All three processes in this case study were carried out solely by the federal government and without a RU involvement, except maybe for negotiating a compensation scheme to subsidize affected fishers by the vaquita ARPEA and the TEGZ.

Local knowledge played an important role in six cases for the co-production of information required for the elaboration of various pieces of SHMI, sometimes prior to implementation for compilation of the EPJ (e.g. RB-ISPM, FRZ-San Cosme, PN-AES) and others after implementation for revisions to the MP or the zonation scheme (e.g. PN-CP). In the case of RB-AGCDRC, local knowledge was not incorporated at all since there were no efforts to involve the RUs. Strong leadership from either RUs (e.g. PN-CP, FRZ-CB, RB-BACBS) or PIPs (e.g. RB-ISPM, FRZ-San Cosme, PN-AES, RB-BACBS) has also played a pivotal role in pushing the implementation of NTA efforts. Non-profit organizations like NIPARAJA, COBI, and PRONATURA are among the most important PIPs mentioned by experts, in some cases with strong positive collaborative schemes with CONANP. An excellent example of PI provision from the non-profit sector is in the case of RB-BACBS in which PRONATURA sought to build a heritage fund for the operation of the NPA through the Mexican Fund for Nature Conservation (FMCN). This fund provided an annual sum of money to aid in the costs of operation for the park, but it was initially managed by PRONATURA until the NPA and the management plan were officially decreed. PRONATURA managed the funds from 2009 until 2012 when CONANP begins to control it after the management plan was published.

Not surprisingly, trade-offs often have to be carefully balanced between proposing NTA designs that strictly align scientific data indicating potential population recovery and spillover effects to adjacent areas (strengthening link 5), and implementing NTAs through a community-supported participative process that empowers local fishers and allows them to become stewards of their environment (strengthening link 6). In two case studies (e.g. FRZ-San Cosme & FRZ-CB), non-profit organizations had to prioritize allowing local fishers to actively participate and dictate most of the design for the proposed NTAs (avoiding highly conflicting areas for fishers) over heavily modifying the designs to suit biophysical and ecological conditions (backed by technical and scientific information).

For example, Aburto-Oropeza et al. (2015) identified two types of rocky reefs in the San Cosme-Punta Coyote Corridor that differ in terms of how much biomass they are likely to harbor. Reefs of complex geomorphology are characterized for being more oceanographically dynamic with more rocky topography, which is associated to high production of certain species (e.g. 50-300 groupers annually). Simple geomorphology reefs have less rocky topography, are less oceanographically dynamic, and are associated with producing much smaller biomasses (e.g. ~2 groupers annually). However, these distinctions were not fully taken into consideration for the design of the FRZ network, which may eventually have an impact for achieving significant fisheries recovery through spillover. Complex geomorphology reefs being potentially targeted by fishers because of better catches means they were likely avoided in the network proposal to avoid conflict with fishing activities. Some FRZs were also designed to be too small to provide significant benefits from a biological perspective.

In a few cases, NTAs placed near the vicinity of clear, identifiable geophysical or geographical features (e.g. RB-ISPM, PN-CP, RB-BACBS, FRZ-CB, FRZ-San Cosme) is considered useful for increasing awareness of the location of NTAs among RUs, though not essential for preventing non-compliance. In ZRP-San Cosme, a lot of the selected sites are located near the communities so they could also be more easily monitored.

2.3.3 Motivations behind support for NTAs and the results of capacity-building

The motivations for fishers to support NTA implementation have varied among all case studies, but is strongly tied to the strengthening of link 6 in almost all cases. Not surprisingly, strong motivation enabling fisher support is the prospect of improving their livelihoods by switching the economic activity they traditionally practiced for new, tangible income-earning opportunities. In the case of PN-CP (Figure 7), a handful of local fishers recognized the value of the biophysical and ecological characteristics of the marine area adjacent to the village of Cabo Pulmo, and saw the potential for the development of an important local eco-tourism sector (e.g. scuba-diving, snorkeling, guided tours) that they themselves could manage. Furthermore, the looming threat of the establishment of large-scale tourism development corporations (e.g. Cabo Dorado and Cabo Cortez) further incentivized fishers to unite and become educated in the business of eco-tourism service provision. However, fishing activities were not too prevalent in Cabo Pulmo before the park was decreed, thus the MP is designed with fishing buffer zones that get very little use from fishing. Non-compliance arises mainly in the form of eco-tourism operators allowing more scuba divers into the park than what is allowed, something the park's administration is actively trying to resolve.

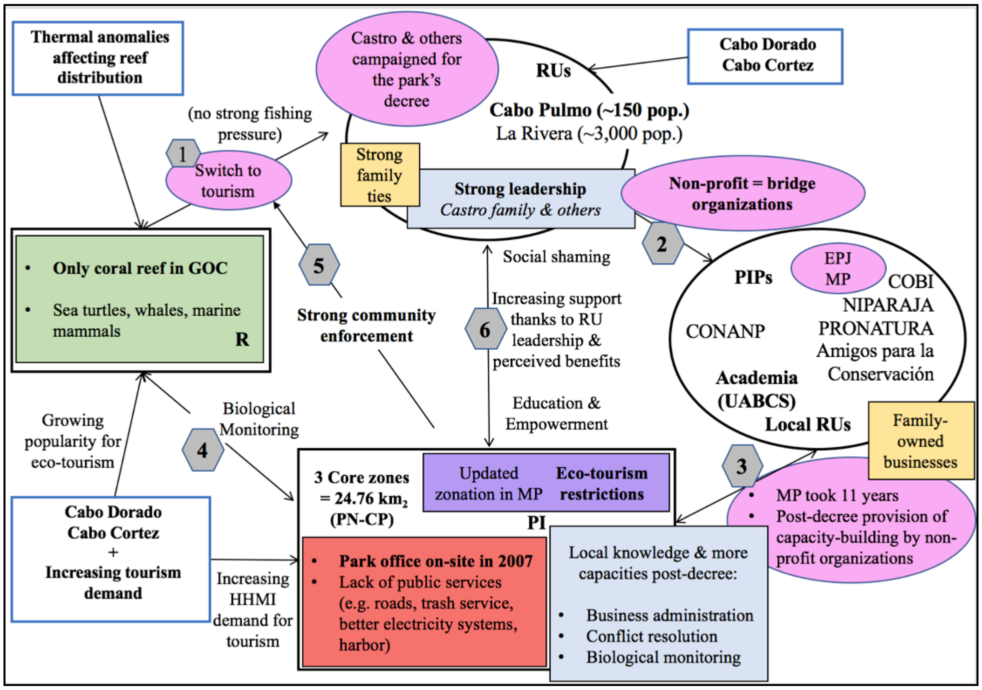

Figure 2.7. NTA-CIS of the National Park of Cabo Pulmo (PN-CP).

Similarly, fishers of Bahía de Kino were not overly concerned with the implementation of the NTA because it was being planned in areas they did not consider essential to their fishing activity and was instead considered the "insurance area" (i.e. where they could go fish when harvesting was low elsewhere in their usual fishing grounds). Furthermore, the long distance (61 km) between Bahia de Kino and RB-ISPM makes it too far and to costly (both in terms of gas money and risk of traveling far by PANGA) for the average local fisher since they need good equipment resources to fish there profitably. Other fisher motivations for supporting NTAs are related to retaining exclusive fishing rights in the buffer zones of the NPAs of the RB category (a condition that does not apply with PNs) (e.g. RB-ISPM, RB-BACBS, RB-AGCDRC). However, this benefit also only applies to those fishers who are legally recognized as holding fishing permits or as part of a registered cooperative with fishing permits, which often means a large number of fishers operating independently cannot enjoy these benefits.

Capacity-building efforts stemming from programs established by PIPs have dramatically increased RU participation in NTA processes, increased awareness of NTA importance and objectives, and led to stronger communication between fishers, locals, and PIPs. The joint efforts from CONANP (through PROCODES programs) and non-profit organization Comunidad y Biodiversidad A.C. (COBI) to implement capacity-building programs for development of various skills and competences (HI, biological monitoring training, leadership skills, promotion of management efforts, education, health, risk management, restoration programs, etc.) were heavily praised in the case of RB-ISPM. Through these programs, community members and fishers of Bahia de Kino have been able to diversify some of their economic activities. These projects are funded yearly by the federal government, and besides providing an additional source of income to the community, "they provide social benefits for increasing well-being through community growth, self-esteem, and stewardship" (pers. comm.). Similar efforts strengthening capacity-building of RUs have been recognized in the cases of PN-CP (post-decree), and in other places where there is still a need for fishing cooperative organization skills (e.g. FRZ-San Cosme). These efforts are usually led by non-profit organizations acting as bridge organizations between the local RUs and the PIPs in charge of elaborating or modifying PI, though this seems be a more recent event (i.e. after 2000).

Some of these programs have even led to new entrepreneurial opportunities for local fishers. In 2007, a consortium of academic institutions and non-profit organizations (PANGAS) supported the organization of a group of diver-monitors composed of local commercial fishers belonging to a fisher cooperative from Bahia de Kino to carry out biological monitoring of the rocky reefs in the northern GOC as well as within existing NPAs. They are recognized for being the first fishing cooperative in Mexico to provide professional monitoring services and earning an additional 10 - 20% of their annual income from providing their services (Munguia-Vega et al. 2015). The operation of these types of efforts, however, is hindered by the need to continue maintaining these efforts, providing both HHMI and SHMI to follow through community projects until they become self-sustaining.

2.3.4 Enforcement and community-compliance-monitoring

Weak enforcement capabilities have been frequently identified within marine resource governance in the GOC (Rife et al. 2013, Cinti et al. 2014, Cisneros-Montemayor and Vincent 2016). With regards to NTAs, CONANP officials and park rangers not having legal authority to ask for fishing permits or take enforcement action towards non-compliers (i.e. they need to be there with someone from PROFEPA, SEMAR, or CONAPESCA's fisheries inspector) is considered an important complication for monitoring NTA compliance.

In some case studies (e.g. RB-ISPM, RB-BACBS), multiple efforts had been made to supplement enforcement capabilities by introducing community compliance monitoring programs. CONANP supports such groups called PROVICOM (*Programa de Vigilancia Comunitaria*) by providing subsidies for participation. Up until recently, RB-

BACBS has had a PROVICOM group of ten people aiding in monitoring for compliance. In cases where NTA is geographically isolated from nearby ports (e.g RB-ISPM), and in conjunction with continued illegal activities which are more likely to occur widespread throughout the GOC (e.g. illegal fishing practices in general, drug trafficking-related activities) experts point out potential serious and undesirable risks to civilians attempting to report non-compliance.

As noted earlier, the case of PN-CP shows how fishers can become motivated to support NTA initiatives once they see clear benefits of the alternative livelihoods they have access to. This process was particularly accelerated by strong leadership from the original supporters of the initiative who convinced the rest of the community that everyone could benefit from transitioning from fishing to eco-tourism service provision (a strong feedback generated by link 6). As a result of this feedback, community members themselves also took on the task of monitoring for compliance with park regulations (including no-take), and sometimes adopting social shaming attitudes even before the park had formal management on site (thus strengthening link 5). Nowadays, practically any local or tourism service operator who observes non-compliance behavior within PN-CP from others will take notice of the offense, take pictures, and report it with PROFEPA (pers. comm.).

Unofficial fishing norms among fishers in various communities appear highly effective given clear incentives and tangible outcomes that are directly perceived by fishers (e.g. PN-CP, RB-AGCDRC). These norms often become part of the community's culture and facilitate conflict resolution, but they can also damage trust relationships if such agreements are not respected. However, there are cases in which these norms are selectively applied and guided by social ties (e.g. FRZ-San Cosme with respect to friends and family members being sanctioned or misuse of fishing ears).

On the other end of the spectrum, experts perceived a general decrease in social shaming attitudes from fishers in FRZ-San Cosme towards non-compliant individuals. This phenomenon seems to be further exacerbated by a culture of apathy towards cooperation among all fishers to comply with no-take regulations, leading to continuous free-riding (i.e. as fishers observe others not complying, they worry less and less about complying themselves). Furthermore, people often rather avoid conflict (e.g. threats or aggressive behavior towards those who report).

2.3.5 Hard infrastructure and information availability

In almost every case study, lack of HHMI was identified as problematic towards addressing enforcement through compliance monitoring (e.g. lack of good patrolling vessels, resources to maintain them, gas money for patrolling trips, binoculars, infrastructure to follow up with non-compliance reports, etc.). In a couple of cases (PN-CP and RB-BACBS), NPAs had no official management office on-site when the NPA became decreed and operational, nor staff. In the case of PN-CP, experts suggested the lack of a formal administrative office as a contributor to the delays for the publishing of the MP since there was no real pressure to finalize it if no one was on-site to effectively implement it (i.e. HHMI causing a delay effect on link 3 for the elaboration of important management guidelines). The provisioning of effective fishing technology HHMI was also identified as critical for addressing fishing threats to charismatic species in the case of RB-AGCDRC (a weakness in link 3). The lack of alternative fishing technologies that are as effective as the traditional gear does not incentivize fishers to stop using destructive gear that leads to overexploitation (e.g. totoaba) or a threat to critically endangered species (e.g. vaquita) (i.e. fishers do not perceive clear incentives to modify their harvesting methods through link 1). Current prototypes for alternative fishing nets often require increased skills from fishers, and the slow progression of transition programs to increase their use (including technical studies demonstrating their success, expedition of fishing permits with new gear, training of fishers to use it), further exacerbates the problem (CIRVA-5 2014).

Accessible information to RUs and other members of the community generally comes in the form of HHMI (e.g. pamphlets, signs, poster boards) and SHMI (e.g. social media, webpages or online platforms (Munguia-Vega et al. 2015)). However, continued meetings held with community members and social marketing campaigns (e.g. RB-BACBS communication campaign and RB-ISPM's pride campaigns via events, parades, wall-painting, t-shirts, talks on the beach, calendars, etc.) are perceived as important venues to transfer knowledge about existing NTAs (e.g. location, importance, restrictions, etc.).

2.3.6 Other economic activities and exogenous drivers

In almost every case study, experts recognize the problem of a large number of SSFs operating without legal fishing permits. These are known as "independent" fishers, and they are considered one of the most disadvantaged RU groups in cases where RB's are implemented. Any exclusive fishing rights NPAs or FRZs can bring to the adjacent communities legally only applies to fishers registered under any sort of fishing permit. Furthermore, the participation of RUs in the processes of designing and implementing NTAs could be heavily biased towards legal fishers if independent fishers fear legal sanctions. The lengthy and elaborated process of obtaining legal fishing permits from CONAPESCA (i.e. multiple requirements such as federal IDs, proof of gear purchases, and trips to large cities to process fishing permits) combined with unawareness of specific fisheries regulations by the fishers, contributes to this growing problem (Cinti et al. 2010a, Cinti et al. 2010b), which creates a negative feedback decreasing RU participation in NTA processes (link 6).

Three major exogenous drivers were identified as having a considerable impact on the resource or NI components in several cases. First, climate change was pointed out as a pressing concern for concern for most NTA efforts in the GOC, and new efforts to improve existing NTAs and implementing new ones are beginning to take potential climate change effects into account (Morzaria-Luna 2016, Álvarez-Romero et al. *in review*). Increasing development of the Mexican tourism sector, partly fueled by the federal government's promotion of the GOC as an important tourism attraction to further stimulate the tourism sector nationally and to encourage foreign investment for the development of tourism infrastructure has also added pressure to many ecosystems under NTA protection. For instance, the promotion of the PN-CP as a pristine, beautiful scuba-diving site, and its subsequent growing popularity, has contributed to the increased pressure from eco-tourists visiting from all over the world, which often exceeds the park's capacity and infrastructure to manage such pressure (especially given the lack of HHMI in the area). Finally, the presence of black markets such as that of the Totoaba species (*Totoaba macdonaldi*) continues to create conflicts in the case of RB-AGCDRC . Increased demand for the totoaba's swim bladder comes mainly from Chinese markets due to their use for medicinal purposes, and it is believed that fishers may receive up to

$8,500 USD/kg for the totoaba bladders. This species is captured in large, anchored mesh gillnets that are set at night and left unattended for several days, and it is then illegally transported via the US-Mexico border (CIRVA-5 2014).

2.4 Discussion

Despite the efforts to implement and spotlight NTAs as strong fisheries management tools for the GOC in the last decade, NTAs in the region have had varying outcomes with respect to their implementation process and subsequent performance. In this chapter, I showed that a CIS-analysis of the social, institutional, and ecological contextual variables provides a powerful diagnostic tool to identify weak links and feedbacks in the different NTA systems of the GOC. In particular, I demonstrate the relevance of three key interactions that can severely impact the effectiveness of NTA implementation processes and performance outcomes.

The first key interaction is associated with the provisioning of soft human-made infrastructure (through link 3) and the various ways in which collaboration and coordination schemes can effectively accelerate (or delay) the processes surrounding NTA implementation and swift operation. The role non-profit organizations play in creating spaces of dialogue, communication, and collaboration among different stakeholder groups has been crucial for various NTA systems of the GOC (and other fisheries management regulations (Espinosa-Romero et al. 2014)). Furthermore, coordination between the non-profit sector and the government environmental and fisheries authorities at the collective choice level also plays a key role in ensuring the provisioning of hard and soft human-made infrastructure has legal backing, thus providing clear regulations that can be implemented and followed at the operational level.

In some cases, this collaboration can even lead to positive outcomes at the constitutional choice level with the creation of new legal instruments for fisheries management (e.g. Fishing Refuge Zones). Effective infrastructure provisioning will certainly aid in the proper functioning of NTAs (a positive feedback influencing link 5) as regulators of fisher behavior towards resource exploitation (link 1).

The second key interaction is associated with the feedbacks generated by effective provisioning (link 3) of hard human-made infrastructure (e.g. new fishing technologies for fishers in the Upper GOC) and mechanisms for transitioning to alternative livelihood strategies (e.g. eco-tourism service provision for fishers in Cabo Pulmo). Effective incentives for fishers to transform their harvesting activities (through link 1) strongly depend on the ability of public infrastructure providers to make these infrastructures directly available to the resource users (i.e. strong link 3) and on how resource users perceive potential costs and benefits (through link 6). If fishers perceive clear, tangible benefits to modify their *modus operandi* and adopt fishing strategies that reduce bycatch and/or are less harmful for the environment, or to transition into new ways to earn income, they are more likely to comply with NTA-type regulations.

Finally, the relationship between the resource users and the different types of soft and hard human-made public infrastructures (link 6) is essential for enabling NTA-type fisheries management tools to effectively regulate the interaction between fishers and the resource they harvest (link 1). The results of multiple capacity-building programs, resource user participation schemes, and increased access to suitable and practical information with respect to fisheries and conservation management strategies clearly demonstrate a positive feedback for the co-production of knowledge and the development of new soft human-made infrastructures in which resource users are heavily involved in. A strong link 6 can create mechanisms by which resource users feel empowered, become stewards of their environment, and even become public infrastructure providers. This process is facilitated by positive and collaborative relationships and occurring through link 2, but it subsequently affects the ability of public infrastructure providers to produce and maintain effective infrastructures (through link 3), as well as engaging in action situations at the collective choice level where decision-making affects the design and operation rules of NTAs.

My results have broad implications for improving the efficacy of NTAs in the GOC by explicitly accounting for governance and socioeconomic objectives of in conjunction with biological objectives. First, capacity-building programs are essential to facilitate the incorporation of resource users and community members into diversified conservation, fisheries management, and economic activities that enable them to engage in alternative livelihoods and become stewards of their environment. Second, public infrastructure provision tradeoffs must be balanced between designing scientifically-sound NTAs with the potential of effectively achieving population recovery objectives and allowing resource users to become co-producers of public infrastructure by fully incorporating their preferences into the design (at the risk of losing ecological effectiveness). Third, a strong and effective collaboration between environmental, fisheries, and other government authorities (e.g. social development authorities, municipal and state governments) is needed to ensure that NTA objectives becomes a clear, shared responsibility among all authority public infrastructure providers equally. Fourth, continued collaboration between non-profit organizations working in different parts of the GOC and government conservation and fisheries management authorities are needed to coordinate efforts leading to the provisioning of SMHI. Finally, the academic sector has a strong role in providing useful information and data in a timely matter so that it becomes readily available for management efforts and NTA initiatives.

While previous work has identified the need for adequate staff and budget as core criteria of effective MPAs at a global scale (Gill et al. 2017), my analysis highlights the importance of multiple infrastructures that can influence the dynamics of interacting action situations at various stages of NTA implementation and operation. Using a CIS lens to look at different components of the system in which NTAs are embedded aids to highlight the interdependencies between the different types of infrastructures and the multiple action situations that influence effective outcomes for NTAs. This type of analysis can be applied to any NTA-system in the world through the synthesis of qualitative and quantitative information depicting the multiple factors related to NTA implementation processes and performance outcomes. Furthermore, linked NTA-CISs can illustrate how different NTAs are contributing to overall performance outcomes at larger spatial and institutional scales.

2.5 References

Aburto-Oropeza, O., E. Ezcurra, J. Moxley, A. Sánchez-Rodríguez, I. Mascareñas-Osorio, C. Sánchez-Ortiz, B. Erisman, and T. Ricketts. 2015. A framework to assess the health of rocky reefs linking geomorphology, community assemblage, and fish biomass. Ecological Indicators **52**:353 - 361.

Agardy, T., P. Bridgewater, M. P. Crosby, J. Day, P. K. Dayton, R. Kenchington, D. Laffoley, P. McConney, P. A. Murray, J. E. Parks, and L. Peau. 2003. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation: Marine and freshwater ecosystems **13**:353-367.

Álvarez-Romero, J. G., A. Munguia-Vega, M. Beger, A. N. Suárez-Castillo, G. G. Gurney, V. M. Adams, R. L. Pressey, L. R. Gerber, M. M. Mancha-Cisneros, A. Castillo-Lopez, M. Kolb, H. N. Morzaria-Luna, H. Reyes-Bonilla, E. Graham, J. VanDerWal, and J. Torre-Cosío. *in review*. Designing marine reserve networks considering ecological connectivity and climate change: a practical application in the Midriff Islands, Gulf of California. Global Change Biology.

Anderies, J. M., M. A. Janssen, and E. Schlager. 2016. Institutions and the performance of coupled infrastructure systems. International Journal of the Commons **10**:495 - 516.

Bernstein, B., S. Iudicello, and C. Stringer. 2004. Lessons learned from recent marine protected area designations in the United States. National Fisheries Conservation Center, Ojai, CA.

Brusca, R., L. T. Findley, P. Hastings, M. E. Hendrickx, J. Torre Cosio, and A. M. van der Heiden. 2005. Macrofaunal biodiversity in the Gulf of California. Pages 179 - 203 *in* J. L. E. Cartron, G. Ceballos, and R. S. Felger, editors. Biodiversity, Ecosystems, and Conservation in Northern Mexico. Oxford University Press, New Yotk.

Brusca, R., and M. E. Hendrickx. 2010. Invertebrate biodiversity and conservation in the Gulf of California. Pages 72 - 95 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Carvajal, M. A., A. Robles, and E. Ezcurra. 2010. Ecological conservation in the Gulf of California. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

CEMDA, and COBI. 2010. Implementacion de Reservas Marinas en Mexico.

Christie, P. 2004. Marine protected areas as biological successes and social failures in Southeast Asia. American Fisheries Society Symposium **42**:155-164.

Christie, P., B.J. McCay, M.L. Miller, C. Lowe, A.T. White, R. Stoffle, D.L. Fluharty, L.T. McManus, R. Chuenpagdee, C. Pomeroy, D.O. Suman, B.G. Blount, D. Huppert, R.L.V. Eisma, E. Oracion, K. Lowry, and R.B. Pollnac. 2003. Toward developing a complete understanding: a social science research agenda for marine protected areas. Fisheries **28**:22-26.

Cinner, J. E. 2007. Designing marine reserves to reflect local socioeconomic conditions: lessons from long-enduring customary management systems. Coral Reefs **26**:1035-1045.

Cinti, A., J. N. Duberstein, E. Torreblanca, and M. Moreno-Baez. 2014. Overfishign drivers and opportuities for recovery in small-scale fisheries of the Midriff Islands Region, Gulf of California, Mexico: the roles of land and sea institutions in fisheries sustainability. Ecology and Society **19**:15.

Cinti, A., W. Shaw, R. Cudney-Bueno, and M. Rojo. 2010a. The unintended consequences of formal fisheries policies: Social disparities and resource overuse in a major fishing community in the Gulf of California, Mexico. Marine Policy **34**:328-339.

Cinti, A., W. W. Shaw, and J. Torre. 2010b. Insights from the users to imrpove fisheries performance: Fisher's knowledge and attitudes on fisheries policie sin Bahia de Kino, Gulf of California, Mexico. Marine Policy **34**:1322-1334.

CIRVA-5. 2014. Report of the Fifth meeting of the 'Comité Internacional para la recuperación de la vaquita'. Ensenada, B.C., Mexico.

Cisneros-Mata, M. A. 2010. The importance of fisheries in the Gulf of California and ecosystem-based sustainable co-management for conservation. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Cisneros-Montemayor, A. M., and A. C. J. Vincent. 2016. Science, society, and flagship species: social and political history as keys to conservation outcomes in the Gulf of California. Ecology and Society **21**:9.

CONANP-SEMARNAT. 1995. Programa de Conservación y Manejo Reserva de la Biósfera Alto Golfo de California y Delta Río Colorado. Mexico, D.F.

CONANP-SEMARNAT. 2007. Programa de Conservación y Manejo Reserva de la Biósfera Isla San Pedro Mártir. Comisión Nacional de Áreas Naturales Protegidas y Secretaría del Medio Ambiente y de los Recursos Naturales, México, D.F. .

DOF. 1978. Decreto por el que se establece una zona de reserva y refugio de aves migratorias y de la fauna silvestre, en las islas que se relacionan, situadas en el Golfo de California. Diaro Oficial de la Federación.

DOF. 1988. Ley General del Equilibrio Ecológico y la Protección al Ambiente, Última reforma publicada DOF 13-05-2016. Diario Oficial de la Federación.

DOF. 2000a. Acuerdo que tiene por objeto dotar con una categoría acorde con la legislación vigente a las superficies que fueron objeto de diversas declaratorias de áreas naturales protegidas emitidas por el Ejecutivo Federal. Diaro Oficial de la Federación.

DOF. 2000b. Ley General de Vida Silvestre, ;ultimas reformas publicadas DOF 13-05-2016. Diario Oficial de la Federación.

DOF. 2005. ACUERDO mediante el cual se establece el área de refugio para la protección de la vaquita (Phocoena sinus).

DOF. 2007. Ley General de Pesca y Acuacultura Sustentables, Nueva Ley publicada en el DOF el 24 de julio de 2007 y última reforma publicada DOF 04-06-2015. Diario Oficial de la Federación.

DOF. 2014. NOM-049-SAG/PESC-2014, Que determina el procedimiento para establecer zonas de refugio para los recursos pesqueros en aguas de jurisdicción federal de los Estados Unidos Mexicanos. .

DOF. 2015. ACUERDO por el que se suspende temporalmente la pesca comercial mediante el uso de redes de enmalle, cimbras y/o palangres operadas con embarcaciones menores, en el Norte del Golfo de California. Diaro Oficial de la Federación.

Espinosa-Romero, M. J., A. A. Rodriguez, A. Hudson Weaver, C. Villanueva-Aznar, and J. Torre. 2014. The changing role of NGOs in Mexican small-scale fisheries: From environmental conservation to multi-scale governance. Marine Policy **50**:290 - 299.

Gill, D., M. B. Mascia, G. N. Ahmadia, L. Glew, S. E. Lester, M. Barnes, I. Craigie, E. S. Darling, C. M. Free, J. Geldmann, S. Holst, O. P. Jensen, A. T. White, X. Basurto, L. Coad, R. D. Gates, G. Guannel, P. J. Mumby, H. Thomas, S. Whitmee, S. Woodley, and H. E. Fox. 2017. Capacity shortfalls hinder the performance of marine protected areas globally. Nature **543**:665 - 669.

Hastings, P., L. T. Findley, and A. M. van der Heiden. 2010. Fishes of the Gulf of California. Pages 96 - 118 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

IMCO. 2013. La pesca ilegal e irregular en Mexico: Una barrera a la competitividad. . México, D.F.

Koch, V. 2015. Análisis Comparativo de Instrumentos para la Conservación y el Uso Sustentable de la Biodiversidad en el Golfo de California. Ciudad de México.

Leslie, H. M., X. Basurto, M. Nenadovic, L. Sievanen, K. C. Cavanaugh, J. J. Cota-Nieto, B. Erisman, E. Finkbeiner, G. Hinojosa-Arango, M. Moreno-Baez, S. Nagavarapu, S. M. W. Reddy, A. Sanchez-Rodriguez, K. Siegel, J. J. Ulibarria-Valenzuela, A. Hudson Weaver, and O. Aburto-Oropeza. 2015. Operationalizing the social-ecological systems framework to assess sustainability. Proceedings of the National Academy of Sciences **112**:5979 - 5984.

McCay, B. J., F. Micheli, G. Ponce-Díaz, G. Murray, G. Shester, S. Ramrez-Sanchez, and W. Weisman. 2014. Cooperatives, concessions, and co-management on the Pacific coast of Mexico. Marine Policy **44**:49 - 59.

McClanahan, T. R. 1999. Is there a future for coral reef parks in poor tropical countries? Coral Reefs **18**:321-325.

Micheli, F., A. Saenz-Arroyo, A. Greenley, L. Vazquez, J. A. Espinoza Montes, M. Rossetto, and G. A. De Leo. 2012. Evidence that marine reserves enhance resilience to climatic impacts. PLoS ONE **7** e40832.

Moreno-Báez, M., R. Cudney-Bueno, B. J. Orr, W. W. Shaw, T. Pfister, J. Torre-Cosio, R. Loaiza, and M. Rojo. 2012. Integrating the spatial and temporal dimensions of fishing activities for management in the Northern Gulf of California, Mexico. Ocean and Coastal Management **55**:111-127.

Morzaria-Luna, H. 2016. Determinación de la extensión y situación actual de reservas marinas en la Región de las Grandes Islas (RGI) y Norte del Golfo de California para reducir los efectos del cambio climático en la producción pesquera y la función del ecosistema. Tucson, AZ.

Munguia-Vega, A., J. Torre, P. Turk-Boyer, S. G. Marinone, M. Lavin, T. Pfister, W. W. Shaw, G. D. Danemann, P. Raimondi, A. Castillo-Lopez, A. Cinti, J. N. Duberstein, M. Moreno-Baez, M. Rojo, G. Soria, L. Sanchez-Velasco, H. Morzaria-Luna, L. Bourillon, K. Rowell, and R. Cudney-Bueno. 2015. PANGAS: An Interdisciplinary Ecosystem-Based Research Framework for Small-Scale Fisheries in the Northern Gulf of California. Journal of the Southwest **57**:337 - 390.

Niño-Torres, C. A., J. Urbán-Ramírez, and O. Vidal. 2011. Mamíferos Marinos del Golfo de California: Guía ilustrada.

Ostrom, E. 2005. Understanding Institutional Diversity. Princeton University Press, Princeton, NJ.

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas.

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science **325**:419-422.

Rife, A. N., B. Erisman, A. Sanchez, and O. Aburto-Oropeza. 2013. When good intentions are not enough...Insights on networks of "paper park" marine protected areas. Conservation Letters **6**:200-212.

Seminoff, J. A. 2010. Sea turtles of the Gulf of California. Pages 135 - 167 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Soberanes Fernández, J. L. 1994. Historia Contemporánea de la Legislación Pesquera en México. Pages 1 - 26 *in* M. González Oropeza and M. A. Garita Alonso, editors. El Régimen Jurídico de la Pesca en México. Instituto de Investigaciones Jurídicas, Mexico.

Yin, R. K. 2014. Case study research: designs and methods. SAGE Publications, Thousand Oaks, CA.

CHAPTER 3

THE ROLE OF STAKEHOLDER PERCEPTIONS AND INSTITUTIONS FOR MARINE RESERVE EFFICACY IN THE MIDRIFF ISLANDS REGION, GULF OF CALIFORNIA, MEXICO

3.1 Introduction

The complex governance of marine resources exemplifies how ecological objectives for the conservation and protection of species and ecosystems can conflict with social, economic, and political objectives for maximum employment yield, economic efficiency, and livelihood support in small communities. Marine protected areas (MPAs), specifically no-take areas (NTAs) where all extractive uses are prohibited, are now widely-used to promote sustainable fisheries and protect marine biodiversity (Fraschetti et al. 2011). However, NTAs have met various levels of success on different countries and under different governance and institutional contexts. In many cases, harvest practices often do not adhere to the formal laws established, especially in developing countries with high levels of poverty and low enforcement capacities. Consequently, many NTAs become “paper parks” that fail to provide ecological and social benefits.

NTAs regulate people directly by restricting their access to designated areas of no-harvesting (Fujitani et al. 2012). Failure to include local communities in the design and implementation of NTA management regulations as well as the resource users’ response to NTA establishment is a common oversight in the design processes of an NTA. Moreover, when these groups are included into the planning process, they are often treated as a homogenous group with respect to their views and actions, which can lead to a partial capture of information that can instigate resistance to implementation and subsequent conflict (Ferse et al. 2010). Nonetheless, stakeholder involvement from the start is essential to foster long-term interest in NTAs (Lundquist and Granek 2005).

Establishing NTAs without consideration of the institutional, social, economic, and political context and governance structure of the region where NTAs are being implemented can be a risky investment for appropriately managing marine resources as it can undermine its objectives and give a false sense of security that such areas will be enough to sustain marine resources (Fujitani et al. 2012, Rife et al. 2013). Moreover, the likelihood that through these efforts MPAs can contribute to providing benefits to local communities can also be compromised. Such "paper parks", in which established NTAs fail to effectively restrict access and exploitation, do not contribute to the recovery of the protected resource (White and Courtney 2004, Rife et al. 2013). Furthermore, there is concern for indiscriminating support of NTA establishment despite the existing knowledge gaps in both the ecological and socioeconomic aspects of their design, which can raise unattainable expectations, lead to a neglect of other effective techniques for fisheries management, and allow inefficient financial expenses on reserve creation and maintenance (Hilborn et al. 2004, Sale et al. 2005).

While there have been efforts to include socioeconomic and governance considerations into the planning and establishment of NTAs around the world in the last decade (Pollnac et al. 2010, Jones 2014), it is not yet clear what governance structures allow or contribute to the success of NTAs. Even though the social and economic benefits of NTAs have been recognized to improve community well-being via increased income from fisheries or tourism, there is a lack of research on governance structures allowing successful implementation of NTAs and how and when the benefits from NTA establishment flow back towards the fishing communities (Cudney-Bueno et al. 2009). Furthermore, little work has been done on the application of a systematic analysis that considers both the biology of the marine resources and the economic conditions in which the management strategies are being applied, as well as the governance and institutional contexts together.

The design and implementation strategies for a NTA system are likely to be more successful when including the ecological, cultural, institutional, and socioeconomic characteristics and operating conditions of the system as a whole. Understanding these characteristics and operating conditions calls for a more holistic view of the process through which NTAs are socially perceived, legitimately implemented, and locally accepted by the actors within the Social-Ecological System (SES). In this chapter, we explore the application of the Coupled-Infrastructure Systems (CIS) framework (Anderies 2015) to a regional case study in the Gulf of California (GOC) in Mexico, to describe some of the common issues that might lead to the problem of NTA paper parks from a governance perspective and we identify where key institutional interactions of the SES are weak and require most attention to improve the effectiveness of existing and future NTA systems. These interactions are extremely important if we think of the set of attributes that affect the preferences, information, strategies, and actions of the natural resource users (Poteete et al. 2010).

In addition to providing lessons on how the performance of formal NTAs within the Mexican context could be improved from a governance perspective, this chapter also addresses the question of whether the perceptions from the different stakeholders with regards to NTAs matches the expectations of what NTAs are expected to achieve in the

GOC, and whether certain strategies for NTA implementation and management are effective for achieving those expectations. There have been multiple studies of governance of marine resources by fishing communities in the GOC (Cudney-Bueno et al. 2009, Cinti et al. 2010a, Basurto et al. 2012, Cinti et al. 2014), yet none have addressed the problems that specific tools like NTAs face at local and regional scales.

3.2 Materials and methods

An understanding of the importance of institutions (i.e., rules, norms, and strategies that humans use to dictate their interactions) to engage in collective action and avoid resource overexploitation (Becker and Ostrom 1995, Basurto and Coleman 2010), as well as the infrastructure through which humans act on the environment (Anderies 2015) is essential to effective resource management. We explore NTAs as a fisheries management tool within the context of the Coupled-Infrastructure-Systems (CIS) framework, where NTAs are a policy instrument (i.e. a piece of public infrastructure) within a SES, to describe how resource harvesters respond to NTA-type instruments and how this response is influenced by the interactions between the biophysical elements of the resource system or natural infrastructure (e.g. the habitats and food webs producing fish), the human-made "hard" infrastructure (e.g. private infrastructure such as the boats and fishing gear for harvesting, public infrastructure such as boats for patrolling NTAs), and the "soft" infrastructure (e.g. the human knowledge on where to fish or NTA boundaries) (Anderies 2015).

The CIS framework aims to understand the broad structure of the components of a SES, their connections, and how their interactions affect the SES's long-term robustness (i.e. it's ability to cope with uncertainty and disturbances from both inside and outside of the system) from an institutional perspective, which enables it to handle environmental, social, political, and economic shocks (Anderies et al. 2004, Anderies and Janssen 2013). The CIS framework is an extension of the Institutional and Development Framework (IAD), which was developed by Ostrom (1990) as a way of understanding the process of policy-making through a systematic approach for analyzing institutions governing action as well as the outcomes of arrangements of collective action. The IAD framework is designed as a conceptual map that identifies a common set of structural variables that are present but variable in different types of institutional arrangement (Ostrom 2011), but which can be extremely useful when evaluating the role of institutions in shaping decision-making processes and social interactions. The CIS framework highlights the dynamic interactions between the exogenous variables identified in the IAD framework (i.e. the biophysical context, the actors, and the rules in use) and emphasizes the interactions between the operational and collective-choice levels of an SES over time (Anderies et al. 2004).

Assessing the problem of paper park NTAs through the lens of the CIS framework allows us to dissect the components and their interactions within a SES affected by the presence of a NTA, identify weaknesses, and understand what components or interactions need improvement to achieve NTA effectiveness within a particular SES. Figure 1 shows a description of each of the components of the CIS framework using a hypothetical example of a NTA system within the Mexican context (Figure 3.1).

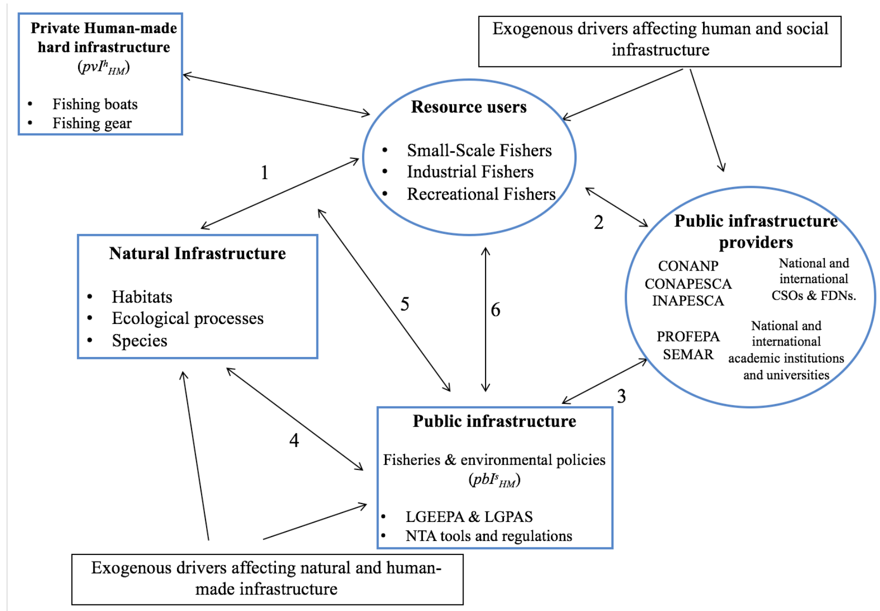

Figure 3.1. Coupled Infrastructure Systems (CIS) Framework depicted with a NTA system in Mexico. The arrows depict the different links between the components of the system (the numbers serve identification purposes only). SSF = Small-scale fishers, IFS = Industrial fishers, RF = Recreational fishers, LGPAS = General Law of Sustainable Fishing and Aquaculture, LGEEPA = General Law of Ecological Balance and Environmental Protection, CONANP = National Commission of Natural Protected Areas, CONAPESCA = National Fisheries and Aquaculture Commission, INAPESCA = National Fisheries Institute, SEMAR = Mexican Navy, PROFEPA = Federal Agency for the Protection of the Environment, CSOs = Civil society organizations, FDNs = Foundations, I^s_{HM} = soft infrastructure, pvI^h_{HM} = private hard human-made infrastructure. Adapted from Anderies et al. (2004), Anderies (2015).

Using a multi-method approach including document analysis and structured interviews with relevant stakeholders, we apply the Coupled-Infrastructure Systems (CIS) framework to a regional case study of three NTAs in the MIR in the GOC to explore and identify potentially relevant variables and interactions to address NTA efficacy within the GOC context. We obtained information on formally established NTAs and the current legislation regulating their establishment and operation in Mexico by examining legal documents and reports elaborated by various federal institutions and Civil Society Organizations (CSOs). Legal documents included environmental and fisheries legislation, and official information (e.g. presidential decrees for national protected areas, management programs). The information obtained from the empirical study on stakeholder perceptions through structured interviews was used to further support the CIS framework analysis and provide more specific insights into where the main barriers to NTA efficacy lie from an institutional perspective.

3.2.1 Study area

Our study area is the MIR within the GOC, Mexico, which is well known for its high levels of biodiversity and productivity in terms of fisheries. The region has been identified as a priority conservation site in Mexico (CONABIO et al. 2007), with 29,898.01 km^2 of territory including 45 islands and islets, which include two of the largest islands in the country: Isla Tiburón (1,224 km^2) and Isla Ángel de la Guarda (936 km^2). The MIR is well known for its diversity of habitats, which include rocky reef systems, *sargassum* forests, rhodolith beds, sand and rocky bottoms, seagrass beds, mangrove forests, and on to a smaller extent sandy beaches and estuaries along the coast. The region has also been recognized for its importance to both small-scale (artisanal) fishing (SSF) and large-scale (industrial) fishing (IFS) (e.g. sardine fishing). Recreational fishers also visit the region frequently, predominantly from the United States and Canada (Fujitani et al. 2012). Most of the SSF activities in the region occur in the rocky reef ecosystems, which are predominantly found all over the coasts of the states of Baja California and Sonora as well as around the islands and islets. There are eight SSF communities in the region, three in the state of Baja California (Bahía de los Ángeles, San Francisquito/El Barril, and San Luis Gonzaga) and five in the state of Sonora (Puerto Libertad, Bahía de Kino, Puerto Lobos, Punta Chueca, and Desemboque de los Seris). Punta Chueca and Desemboque de los Seris are the only two communities in the MIR that are home to the group of indigenous people called the Comcaac (Seri), who possess exclusive fishing rights over the use of natural resources on the 91,000 ha of coastal area as well as the coastal waters off Isla Tiburón (including the strip of water known as Canal del Infiernillo), granted by presidential decree in 1975 (Carvajal et al. 2010).

3.2.2 Stakeholder perceptions

To better understand the dynamics of the NTA system at a local scale, we carried out an empirical study on stakeholder perceptions towards the use of NTAs for conservation of biodiversity and management of fisheries in three local communities in the MIR. Between the months of October 2014 and March 2015, we conducted structured interviews based on previously identified potential caveats within the NTA systems, according to the CIS framework. Interviews were implemented for three local communities in the GOC: the Sonoran communities of Puerto Libertad (pop. 2,782) and Bahía de Kino (pop. 6,050), and the village of Bahía de los Ángeles in Baja California (pop. 800) (INEGI 2010). A total of 184 interviews were carried out to members of the most relevant stakeholder groups in the Midriff Islands Region (Table 3.1) from two key actor group categories: 1) *Direct Resource Users (RUs)*, which included SSF and IFS who are active, retired, registered, independent (non-registered), permit holders, and representatives of fishing cooperatives, as well as members of the general community (GC) whose source of income is to a lesser extent linked to fishing activities (e.g. catch processing, gear mending); and 2) *Public Infrastructure Providers (PIPs),* which included representatives from fisheries management (GFA) and environmental agencies (GCA) as well as civil society organizations (CSOs) and foundations (FDNs) that frequently sponsor research and conservation programs in the region. A pilot study was implemented in Bahía de Kino in July 2014 with representatives from the general communities, conservation agencies, and SSF to test and adapt the interview process.

Table 3.1. Respondents from two key actor groups for the interview process.

Stakeholder Group	n
Public Infrastructure Providers (PIPs)	48
Conservation agencies (GCA)	19
Fisheries agencies (GFA)	13
Civil Society Organizations (CSO)	8
Foundations (FDN)	8
Direct Resource Users (RUs)	136
Small-scale-fishers (SSF)	124
Industrial fishers (IFS)	4
General community (GC)	8

Data from interviews were used to characterize stakeholder perceptions about NTAs, including the level of understanding and support for NTAs among the key actor groups, and how this support vary among these groups. The structured interviews included: demographic information about respondents (age, sex, place of birth); employment (*for RUs:* history of fishing, method of fishing, species targeted, alternative livelihood options or sources of income); organization (membership in formal or informal groups, and attendance to capacity-building workshops related to NTAs); and perceptions on current state and threats for biodiversity and fisheries management, benefits from NTAs, compliance with NTA regulations, and the process and performance of existing tools for NTAs in Mexico and their regulations. Out of the 136 RU respondents, 46 belonged to a given conservation or capacity-building working group (e.g. community biological monitoring teams, fishing committees, and regulation monitoring groups). Fifty-five RU respondents had also been involved in recent capacity-building workshops with respect to NTAs, how they work, and what has been learned through the use of NTAs for both biodiversity and fisheries management in Mexico and around the world. We assessed perceptions through open-ended questions and statements with a five-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree).

RUs were on average 40 years of age (17 – 70 age range) employed in the fisheries sector an average of 22 years (up to 58 years) of and a male/female ratio of 33:1. PIPs were on average 45 years of age (25 – 71 age range) in their respective employments as members of environmental or fisheries management agencies an average of 15 years (up to 40 years) of and a male/female ratio of 2:1.

3.3 Results

3.3.1 No-take areas through the lens of the Coupled-Infrastructure-Systems Framework

In using the CIS framework to evaluate a SES affected by the presence of a NTA, the framework includes four components, including two sets of actors (RUs and PIPs; circles) and two sets of infrastructure (natural and public; rectangles) (Figure 3.1). Within the actors, the RUs include SSF, IFS, recreational fishers (although not included in this study) individuals involved in fish processing and other fishery-related activities on land, community members as consumers (GC), indigenous groups living in the region nearby the NTAs, and tourists. SSF are the most important source of income for the majority of inhabitants of the coastal communities in the region (Ulloa et al. 2007), and multiple communities converge on their fishing activities year-round, mainly around the MIR (Moreno-Báez et al. 2012). Due to its strategic geographic position as a close access point to the sea for U.S. residents from Arizona, California, and other southwestern states, recreational activities are common among foreign recreational angler fishers. Many of these RFs become semi-permanent residents in the region, particularly in towns like Puerto Peñasco and Bahía de Kino (Fujitani et al. 2012). The Comcaac, who live in villages on the state of Sonora, hold exclusive fishing rights of some of the coastal territory in the Sonoran coast as well as in Isla Tiburón (Basurto et al. 2000, Basurto et al. 2012).

In terms of *private hard human-made infrastructure* (pvI^{h}_{HM}), SSF work with hand-operated gear such as gill nets, diving, hook and line, hand fishing line, traps, and longlines, that they use in small 6-8m long small skiffs (pangas) made of fiberglass with outboard gasoline motors (55 – 150 hp). IFS operate on diesel-run industrial vessels of ~150 metric ton capacity that can operate more mechanized gear such as purse seine nets, trawl nets (paired, bottom, and midwater), long lines, and gill nets (Cisneros-Mata 2010). In the northern GOC, including the MIR, some communities are known for having the capacity to travel long distances to reach their fishing grounds (Moreno-Báez et al. 2012). For instance, fishers of Bahía de Kino have been reported to travel the farthest within the MIR, with travel distances between 180 and 200 km for certain species caught via dive fishing, gill nets, and longline fishing, whereas near shore fishing grounds reach up to 60 km from the shore for trap crab fishing (Moreno-Báez et al. 2012). Bahía de Kino is also the oldest fishing town in the northern GOC, operating since the 1930s, thus having a long history of resource harvesting and depletion of nearby fishing grounds which requires fishers to travel longer distances to find suitable fishing grounds. Furthermore, Bahía de Kino is located near (100 km) the state capital Hermosillo and 400 km from the USA-Mexico border, thus having access to better *public hard human-made infrastructure* (pbI^{h}_{HM}) such as good access to major roads and processing plants.

With regards to *soft infrastructure* (I^{s}_{HM}), the fisheries' dynamics in the Gulf are driven by seasonality and *de facto* open access, and fishery catch data and statistics are highly uncertain in Mexico (Cisneros-Montemayor et al. 2013), which make actual fishing effort difficult to evaluate. However, it is estimated that ~50,000 SSF operate 25,000 pangas in the region. In terms of effort, nearly 18,000 pangas operate in a given year in the Gulf, with nearly 90% operating during the shrimp season (September to March) to then shift to other resources or stop fishing at the end of the season. Local SSF have vast knowledge on ecological processes responsible for spawning seasons, which is of great value for determining the spatial and temporal dimensions of fishing activities in the northern GOC as fishers base their decisions of where and when to fish on said knowledge (particularly for the shark, rays, and swimming crab fisheries) (Moreno-Báez et al. 2012). In terms of industrial fishing, some 10,000 IFS work on approximately 1,300 industrial vessels with crews ranging from five (on shrimp trawlers) to eleven people (in squid and sardine vessels) (Cisneros-Mata 2010).

The PIPs include GCAs & GFA, monitoring and enforcement government agencies, CSOs working in the region and scientific researchers from both Mexican and International academic institutions. PIPs provide support for legislation changes, conservation and management programs, capacity-building programs and organizational, communication, and collaboration support for conservation and management activities as well as for scientific research.

In Mexico, the management of marine resources is shared between two sets of federal authorities, the SAGARPA (*Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food*) and the SEMARNAT (*Secretary of the Environment and Natural Resources*), each of which house several federal agencies in charge of fisheries and environmental issues, respectively (Cinti et al. 2010a, Cinti et al. 2014). SAGARPA houses the National Aquaculture and Fisheries Commission (CONAPESCA), which is the primary agency in charge of designing, implementing, and enforcing fisheries and aquaculture policy regulations, as well as the National Research Fisheries Institute (INAPESCA), which is the scientific backbone of CONAPESCA. CONAPESCA operates mainly by issuing and managing fishing permits, concessions, or authorizations, in accordance with the *General Law of Sustainable Fishing and*

Aquaculture (LGPAS). SEMARNAT houses two federal agencies relevant for the functioning of NTA: the National Commission of Natural Protected Areas (CONANP) who is solely responsible for the establishment and management of federal NPAs in accordance with the *General Law of Ecological Balance and Environmental Protection* (LGEEPA), and the Federal Agency for the Protection of the Environment (PROFEPA), the main administrative agency in charge of monitoring compliance of environmental protection regulations.

In addition to the conservation and fisheries federal authorities, national and foreign academic and scientific institutions have provided most of the information and knowledge about the ecosystems of the GOC since the 1950s (Carvajal et al. 2010). The GOC is considered one of the most well-studied regions in Mexico in terms of its natural history and biodiversity, and it has gone through seven marine planning exercises in the past 18 years (Álvarez-Romero et al. 2013). However, despite of a long tradition of conservation planning, it also has a history of lacking effective fisheries governance, which has led to highly uncertain catch data and fishery statistics (Cisneros-Montemayor et al. 2013).

Finally, the GOC has had a strong presence of Mexican CSOs as well as international non-governmental organizations funded by both national and international foundations (FDNs) for projects related to both conservation and management of natural resources within Mexico since the 1980s (Herman 2004). These CSOs have not only provided some of the infrastructure to aid in the application of conservation and fisheries management actions in the region, but they have also have supported scientific projects and compiled much of the local knowledge coming from the local users in the region.

The Mexican Fund for Nature Conservation (FMCN) is one of the main national organisms responsible for organizing and distributing funds from various international foundations to support protected areas in Mexico (Rife et al. 2013). Some of the CSOs promoting marine conservation and sustainable fisheries are Comunidad y Biodiversidad A.C. (COBI), Sociedad de Historia Natural Niparajá A.C. (NIPARAJÁ), Noroeste Sustentable (NOS), Pronatura Noroeste (PNO), SuMAR, and Voces por la Naturaleza, while international NGOs include Conservation International (CI), Environmental Defense Fund (EDF), The Nature Conservancy (TNC), and World Wildlife Fund (WWF). Furthermore, CSOs also began to expand their work from having mostly focused on environmental issues (e.g., protection and recovery of endangered species, habitat protection, and natural protected areas) to also working on issues of sustainable fisheries management (Espinosa-Romero et al. 2014), promoting the use of traditional knowledge (Basurto et al. 2012), improvement of scientific information (García-Hernández et al. 2015) and its integration with traditional knowledge (Cinti et al. 2010b, Moreno-Báez et al. 2012), supporting the development of new management plans for commercial species (Cisneros-Mata et al. 2014, Zepeda-Domínguez et al. 2015), supporting environmental education as well as education on existing fisheries management tools and regulations (Meza-Monge et al. 2015), and promoting community-oriented processes (e.g. strengthening fishers' organization and participatory processes, local capacity-building, etc.) (Basurto et al. 2000, Espinosa-Romero et al. 2014).

Within the two sets of infrastructure, the *Natural Infrastructure* (NI) includes the resource itself (e.g. commercial fish and invertebrate species targeted by both SSFs and IFs) and the biophysical components and conditions that comprise the ecosystem and habitats where the resource resides. In the GOC, the combination of unique oceanographic and physiographic features, along with high year-round nutrient levels that support exceptionally high rates of primary productivity and complex food webs (Díaz-Uribe et al. 2012), render it one of the most biologically productive and diverse seas in the world (Brusca et al. 2005, Lluch-Cota et al. 2007). In the MIR, SSFs target at least 80 importantly commercial species in the region, ranging from ray-finned fish (e.g. leopard grouper, yellow snapper, spotted sand bass), to cartilaginous fish (e.g., hammerhead shark and diamond stingray), to crustaceans (e.g., swimming crab, blue shrimp, and spiny lobster), to mollusks (e.g., octopus and rock scallop), to echinoderms (e.g. sea cucumber). IFs generally target 6 main species guilds, including squid, anchovy, skipjack, sardine, tuna, and shrimp, with the latter three being the most important (Moreno-Báez et al. 2012). These species thrive in the region due to the presence of rocky reef habitat as well as mangroves, non-mangrove wetlands, *sargassum* forests, and seagrass beds acting as nursery habitat for the growth and reproduction of many species.

The *Public Infrastructure* (PI) includes any formal or informal arrangement that establishes a NTA and all the regulations that come with them. While NTAs have been established in Mexico, an explicit regulation to design, establish, monitor and evaluate NTAs as a whole unit in the marine realm has not been created within the Mexican legislation (CEMDA and COBI 2010). Therefore, it is the tendency in Mexico that the environmental laws of land protection be used as an extension to the marine environment. There are thus multiple tools within both the conservation and environmental protection legislation realm and the fisheries legislation realm that can be considered to function as NTAs. Currently, there are four distinctly different types of tools and schemes that are commonly used in the GOC that act as NTAs: Core Zones within Natural Protected Areas (NPA), Fishing Refuge Zones (FRZ), Voluntary Marine Reserves (VMR), and NTAs due to national security (NTANS) (which indirectly become NTAs since no fishing activity is allowed within due to national security reasons) (Torre et al. 2016). These three tools are established and managed by different agencies and governing bodies.

NPAs are defined as "zones within the National territory where the original environment has not been modified significantly by human activity or that require preservation and restoration" (LGEEPA, Art. 44). There are four different types of NPAs containing a zone called a *core* zone which would be considered NTAs, two of which exist in the MIR: Biosphere reserves (RB) and National Parks (PN), which mainly differ by the RB's inclusion of community participation and exclusive fishing rights for the nearby local communities on zones where sustainable fishing is allowed (called *buffer zones*) within the NPA. NPAs are permanently decreed areas under the jurisdiction of CONANP as far as their design, establishment, management, patrolling on-the-grounds, and biological monitoring and evaluation activities. Although enforcing and sanctioning those who infringe on NPA regulations lies within PROFEPA's jurisdiction, CONANP can summon both PROFEPA and the Mexican Navy (SEMAR) when needed to participate in enforcement activities.

FRZs are a relatively new instrument for the establishment of NTAs in Mexico. FRZs are defined as "areas within federal jurisdiction established with the main purpose of conserving and contributing, either naturally or artificially, to the development of the fishery resources within it (based on their reproduction, growth and recruitment), as well as preserving and protecting their surrounding environment" (LGPAs, Art. 4). These areas, which are decreed for two to 6 years and managed by CONAPESCA, have both temporal and permanent NTAs that are established for the protection and recovery of commercially important fishery species (including their various reproductive stages and spawning aggregations) considered to be overexploited. Some FRZs are also decreed to complement other existing conservation measures, including those within NPAs. The first network of FRZ was established in 2012 in the Baja California Sur peninsula (Corredor San Cosme-Punta Coyote) south of the MIR, where eleven areas where closed to all fishing for a duration of 5 years after its decree. The establishment of this network of FRZs prompted the formal publication of the official decree that determines the legal standards and procedure for the establishment of FRZs in 2014 as the NOM-049-SAG/PESC-2014 (DOF 2014), followed by the establishment of other five FRZs in Mexico by 2016. Nonetheless, FRZs present an example of another NTA-type management tool with a shorter duration, a stronger emphasis on fish stock recovery, and under a different management agency's jurisdiction (CONAPESCA) that is currently being sought-after by other communities within the GOC (e.g. in Puerto Libertad, Sonora, and in some communities in the Upper GOC) as an alternative to NPAs.

VMRs represent the third commonly used tool to establish fully protected marine areas in Mexico. While strong in these areas are robust in terms of stakeholder buy-in and social acceptance, they have no legal backing within the Mexican environmental or fisheries legislation, and are thus subject to being completely under the jurisdiction of the fishing communities that seek their establishment. These areas are typically established via community-agreements and maintained by particular fishing groups, cooperatives, or with the help of local NGOs working in the area. Although no VMRs remain currently active in the GOC, there are other examples of VMRs that have had certain levels of success in other communities within the Baja Pacific Region and other parts of Mexico (Cudney-Bueno et al. 2009, Micheli et al. 2012, Revollo-Fernández 2012).

Finally, No-Take Areas for National Security reasons (NTANS) are areas decreed by the SCT (Secretariat of Roads and Transportation), and other dependencies, where no fishing is allowed surrounding oil drilling platforms managed by Petróleos Mexicanos (PEMEX) or electrical infrastructure managed by the Federal Commission of Electricity (CFE) (e.g. NTA adjacent to a CFE plan in Puerto Libertad) (Torre et al. 2016).

Public Infrastructure (PI) includes all these different types of tools and their regulations, though it can also include others within the environmental and fisheries legislation that may not be directly related to the NTA's but that can affect their establishment, management, and functioning. Three NPAs have been decreed within the MIR (Figure 3.2, Table 3.2), each with their own NTAs (Figure 3.3).

Table 3.2. Natural Protected Areas (NPAs) in the Midriff Islands Region in the GOC (Bourillon and Torre 2012, Moreno-Báez et al. 2012, Rife et al. 2013). MP = Management Program.

NPA	RBISPM	PNASL	RBBACBS
Name	Reserva de la Biósfera Isla San Pedro Mártir	Parque Nacional Archipiélago de San Lorenzo	Reserva de la Biósfera Bahía de los Ángeles, Canal de Ballenas y Salsipuedes
Total NPA area (km^2)	298.76	584.42	3,879.57
Total no-take area	8.21 km^2 2.74 %	88.05 km^2 15.06 %	2.07 km^2 0.05 %
Year NPA decreed	2002	2005	2007
Year MP decreed	2011	2014	2014

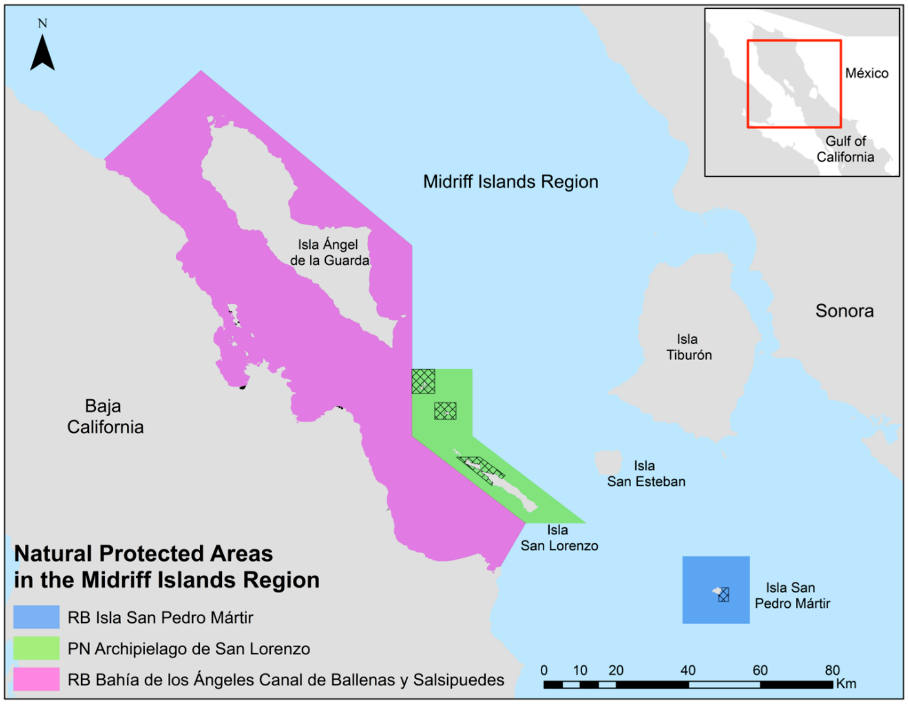

Figure 3.2. NPAs within the MRI region in the GOC. RB = Reserva de la Biósfera, PN = Parque Nacional.

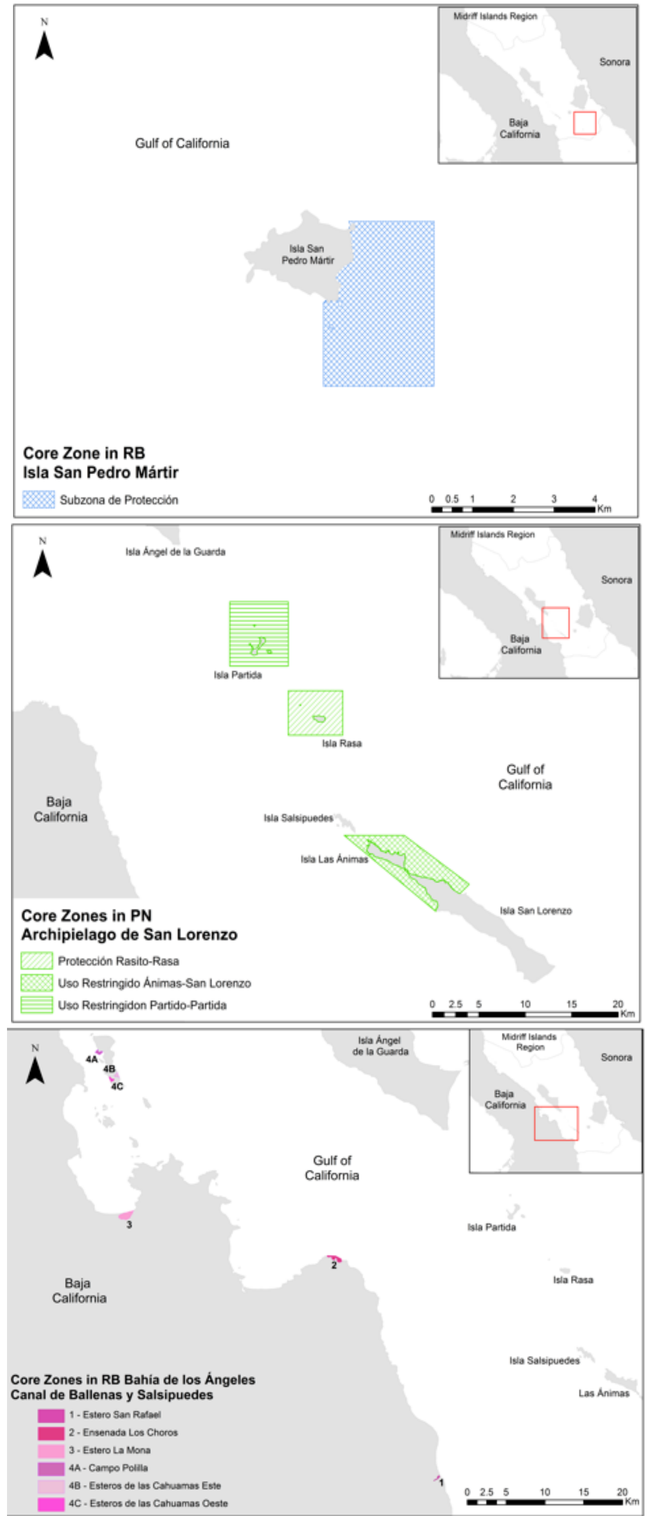

Figure 3.3. NTAs within NPAs of the MRI region in the GOC.

The CIS framework also considers exogenous drivers that can affect human and social infrastructure (e.g. political initiatives for establishing protected areas, changes in government offices, new legislation, etc.). In the last couple of decades, NPAs within Mexico had been implemented opportunistically when political will and current agendas facilitated the process (Rife et al. 2013). Nowadays this trend seems to be changing with more and more participation from CSOs and other organizations in the process of establishing NTAs that protect marine ecosystems without affecting local stakeholders. Finally, exogenous drivers that can affect the natural and human-made infrastructure are also considered (e.g. the effects of climate change or climate phenomena like El Niño and La Niña). Recent studies on the interaction of climate change effects with the spatially-explicit restrictions of marine NPAs in the GOC suggest regional variation on their resilience to climate change, with some areas closed to fisheries ameliorating the negative effects on biomass (Morzaria-Luna 2016), while other studies attempt to identify Gulf-specific effects of rising sea surface water temperatures on important fishing commercial species (Précoma de la Mora 2015, Ayala-Bocos et al. 2016). Consequently, federal environmental agencies (including CONANP) and many conservation CSOs in the GOC are now including strategies for incorporating ecological connectivity and planning for climate change adaptation within their management plans and long-term programs.

Finally, the CIS framework considers the different types of interactions or links among all components of the system (numbered 1-6 in Figure 3.1). This way we can identify where weaknesses or strengths are occurring in the system and what consequences it can bring to the long-term robustness of the system. The purpose of these links is to allow the exploration of how different possible policy processes might function in a dynamic policy context, and assess the fit between the biophysical context, the actors, and the rules and regulations in the system (Anderies and Janssen 2013).

3.3.2 Stakeholder knowledge, perceptions, and preferences

3.3.2.1 Resource User knowledge on local NTAs

For each individual NPA, fishers were asked if they were aware that such NPA existed, and if so, if they knew the location of the NTA within the NPA. Fishers were also asked if they believed that such NPA had been successful for the conservation of biodiversity as well as for fisheries management. RUs showed critical gaps in their knowledge on NTAs within the current established NPAs in the region, with 15.4 % of respondents not knowing about the existence of any of the three NPAs, yet of those who knew about them 44.4 % of them did not know the precise location of the NTAs. Only 21.3 % of respondents knew about all three NPAs, yet only 7.5% of them knew the location of all three NTA systems.

The NPA of RBISPM was the most well-known NPA, while PNASL was the least well-known despite having the largest area with no-take regulations (Table 3.3). However, these results may be related to sampling sizes from each community and to the fact that Sonoran RUs are known for being more mobile than those of Baja California. The NTA of RBISPM was decreed after the establishment of the terrestrial NPA as an extension of the terrestrial NPA, and the process was accompanied by a large community-involvement campaign in the community of Bahía de Kino with the goal of empowering the community members as stewards of their environment. Although the NPAs of PNASL and RBBACBS, were decreed at different times and each has its own

Management Program, they are jointly managed by CONANP's administrative offices, and they are considered to serve different objectives. The NTAs within RBBACBS harbor mainly coastal and mangrove habitat that work as nursery grounds for important commercial species, but these areas are usually not harvested by fishers. The NTAs are also within proximity of the nearby villages, including Bahía de los Ángeles. The NTAs within PNASL surround four of the islands harboring some of the most important seabird breeding colonies in the GOC.

Table 3.3. Percentage of respondents who are aware of the existence of NPAs and the boundaries of the NTAs. PNASL = Parque Nacional Archipiélago de San Lorenzo; RBBACBS = Reserva de la Biosfera Bahía de los Ángeles, Canal de Ballenas y Salsipuedes; RBISPM = Reserva de la Biosfera Isla San Pedro Mártir.

	RBISPM	PNASL	RBBACBS
Aware the NPA exists	63.2%	37.5%	52.9%
Knows NTA location	44.1%	15.4%	22.1%

3.3.2.2 Non-compliance with the restrictions of no-fishing within NTAs

In terms of perceptions of non-compliance with NTA regulations by RUs who knew the location of NTAs, 83.2 % of respondents believed there were problems of non-compliance within one, two, or three of the NTA systems in the region (10.6 % responded to not believe there were issues of no-compliance, and 6.2 % were not sure). Figure 3.4 shows responses when fishers were asked what their usual reaction to the observation of non-compliance to no-fishing restrictions within known NTAs was.

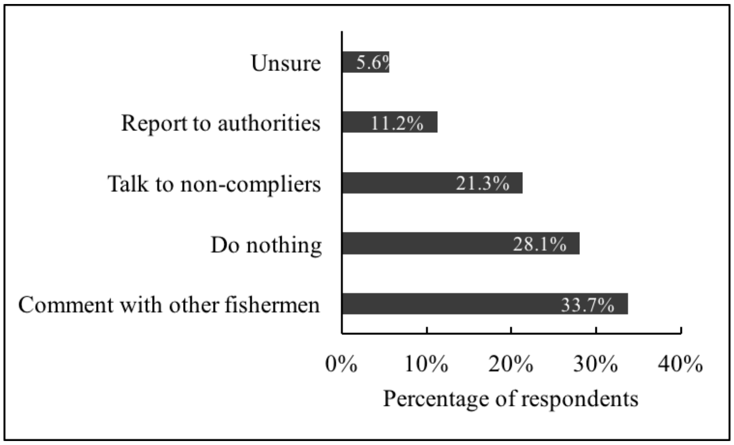

Figure 3.4. Responses from SSFs, who did observe non-compliance with no-take regulations in any of the NTAs of which they knew the location, to the question "What action do you usually take when you observe non-compliance within the NTA?".

3.3.2.3 Perceptions on levels of success of current NTAs in the region and preferences for NTA-type tools

RUs and PIPs had different levels of agreement on the level of success that existing NPAs have had for the management of biodiversity and fisheries within the region. PIPs stated more confidence in NPAs in the region being successful for the conservation of biodiversity (60.4 % stating they are successful, 12.5 % stating they are not, and 27.1 % unsure) than for fisheries management (43.8 % stating they are successful, 22.9 % stating they are not, and 33.3 % unsure). Among the different key actor groups within the PIPs, both government agencies and foundations seemed most optimistic than CSOs about the level of success NPAs had for both conservation of biodiversity and fisheries management, although CSOs seemed to be less optimistic about the ability of the current NPAs in the MIR to achieve successful outcomes with respect to fisheries management (Figure 3.5). Within government agencies, representatives from the fisheries management agencies generally did not perceive current NTAs as successful or were unsure about their current achievement or potential for effective fisheries management, whereas environmental agencies were more optimistic (Figure 3.6).

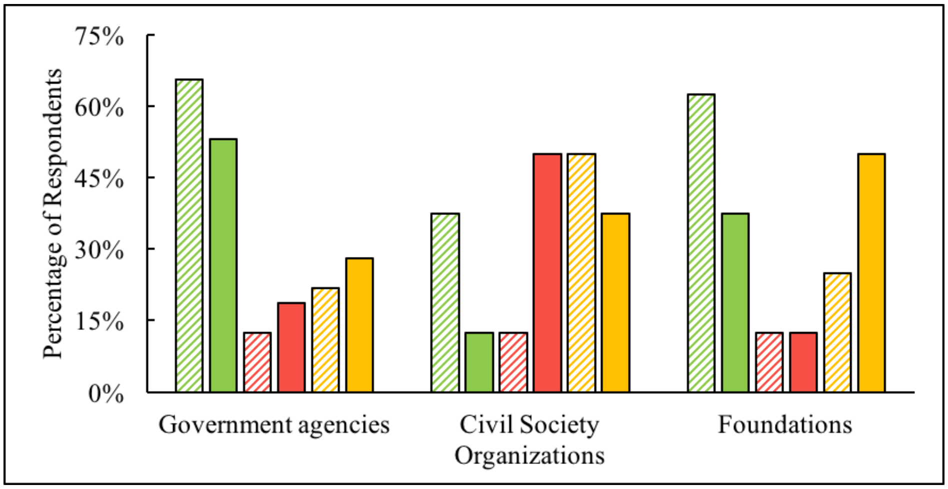

Figure 3.5. Perception among *PIPs per sector* about whether existing NPAs, in general, have been successful for the conservation of biodiversity (*striped*) and for fisheries management (*solid*). Green = Yes, Red = No, Yellow = Unsure.

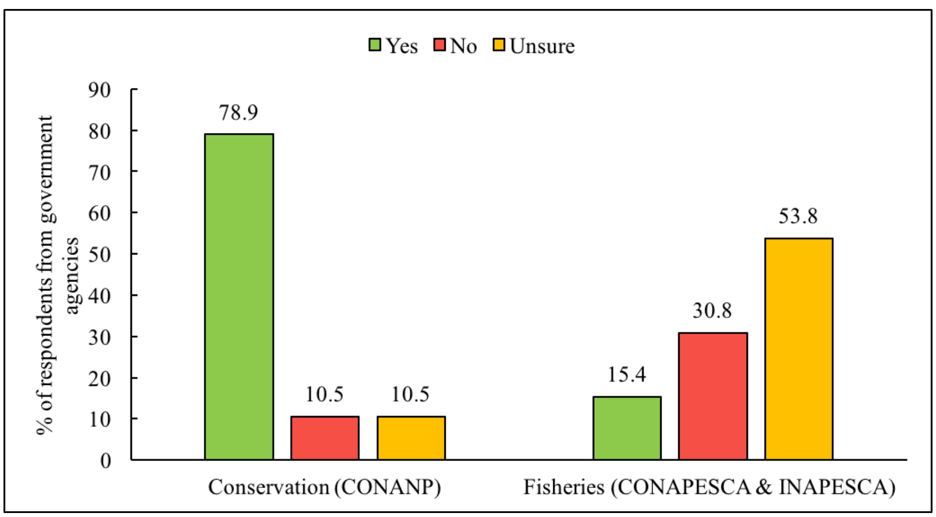

Figure 3.6. Perception among *the government agencies sector* about whether existing NPAs, in general, have been successful for fisheries management (*right*).

RUs were specifically asked about their perceived level of success for each of the NPAs that they were familiar with since their harvesting activity is very localized and they can provide direct feedback on the effects of conservation and management actions in the area. Fishers who were familiar with the RBISPM seemed more optimistic about the level of success of the NTA with regards to conservation of biodiversity, and to a lesser extend to fisheries management (Table 3.4). On the other hand, fishers familiar with the PNASL seemed most skeptical about the success of NPAs for conservation, but even more greatly about their success for fisheries management (only 9.3 % of respondents perceived the NPA successful for fisheries management). Nonetheless, 79 % of RU respondents recognized the benefits of NTAs in general include higher reproduction rates of commercially important species, more catches and thus higher economic benefits for fishers.

Table 3.4. NTA-specific perception among RUs (mostly SSF) about whether existing NPAs have been successful for the conservation of biodiversity and for fisheries management.

	PNASL		**RBBACBS**		**RBISPM**	
NPA successful for:	Conservation	Fisheries	Conservation	Fisheries	Conservation	Fisheries
Yes	28.8%	9.3%	49.3%	38.9%	60.9%	45.5%
No	19.2%	29.6%	11.3%	22.2%	12.6%	22.7%
Unsure	51.9%	51.9%	39.4%	38.9%	26.4%	31.8%

In general, RU respondents had little knowledge with respect to the process for establishing NTAs in Mexico, but they had a similar perception to the PIP respondents on the usual timeline for the establishment of NTAs. Among both RUs and PIPs, most respondents believed the establishment of NTAs would take between two and five years (42.1 % of RUs, 60.4 % of PIPs), although more RUs expressed uncertainty with this estimate than PIPs (33.9 % of RUs, 10.4 % of PIPs). Half of the RU respondents also expressed that the establishment of NTAs should only take a year or less, and the other half believed it should not take more than 5 years.

In terms of the RUs preference with respect to which NTA-type tool would be most appropriate for the establishment of future NTAs in the MIR, VMRs was the tool preferred to be the first choice for 58.9 % of the RU respondents, with 26.6 % preferring NPAs and 18.5 % preferring FRZs, whereas FRZs were chosen as 2nd choice by 45.2 % of the respondents (Figure 3.7).

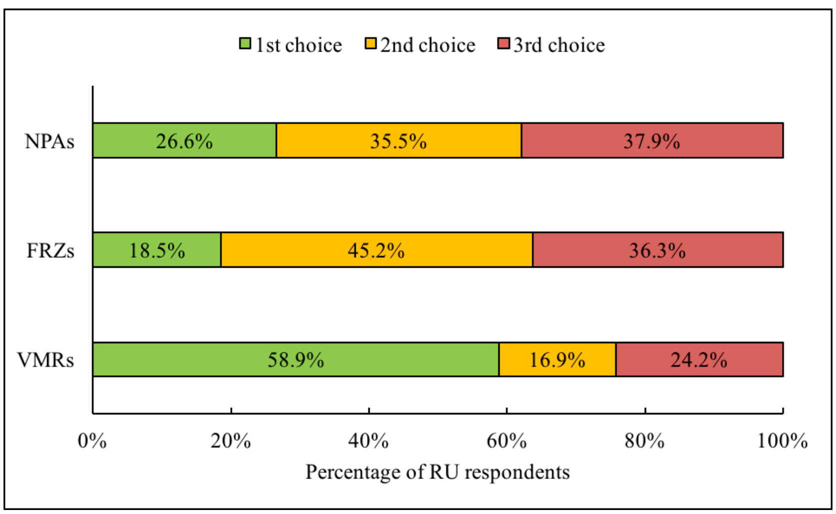

Figure 3.7. RU Response to question: Which NTA tool would be your first, second, and third choice for the establishment of a network of NTAs? NPAs = Natural Protected Areas, FRZs = Fishing Refuge Zones, and VMR = Voluntary Marine Reserves.

3.4 Discussion

Over the last decade, studies on the knowledge and perceptions of resource users in the GOC towards formal fisheries management policies that exclusively regulate harvesting activity have shared important lessons to improve stewardship of fishery resources. The need to formally recognize fishers as key stakeholders in local fisheries and include them in the cooperative design of management strategies and regulations has been shown to be critical for effective fisheries management (Cinti et al. 2010b). However, the formal institutional structure of Mexican fishing regulations may not be the most effective strategy to promote responsible fishing behavior (Cinti et al. 2010a). Insufficient government support for the provision of secure fishing rights, effective enforcement and sanctioning mechanisms, and the recognition and incorporation of local arrangements and capacities into management actions has all been shown to undermine sustainable fishing practices in the GOC, and especially in the MIR (Cinti et al. 2014). More importantly, higher levels of governance have also been shown to be a major impediment to sustainable fishing practices among SSF when disconnected from local practices, realities, and needs of the local communities (Cinti et al. 2014). Our results build on this foundation and contribute to the understanding of NTAs as fisheries management tools within the Mexican policy context.

Previous institutional analyses for some of the communities in the GOC have suggested potential weak interactions (links on Figure 3.1) on how RUs and PIPs behave with respect to the establishment of NTAs, and how it has led to shortcomings when using NTAs for fisheries management (Mancha-Cisneros and Gerber 2015). My results narrow down these weaknesses to (a) different levels of knowledge and support for NTA-type tools in the region; (b) non-compliance and apathy among the community members towards NTAs; and (c) differences in perceptions between the RUs and the PIPs with regards to the success of NTAs and what they can accomplish. Additionally, all NTA-type tools are vulnerable to external ecological (e.g. climate change) or political disturbances (e.g. new legislation, changes in government office). These weaknesses, likely occurring due to insufficient consideration of social buy-in processes during the design and establishment phases for NTAs, can interfere with NTA performance to achieve fisheries management objectives.

With regards to levels of knowledge and support for NTAs, there are still information gaps with regards to NTAs in the region despite strong efforts from CSOs and some GFAs and GCAs to provide workshops, organize working groups, and disseminate relevant information among the various fishing communities. In other words, there is a weak presence of soft human-made infrastructure that leads to knowledge on no-fishing restrictions, boundaries, and the consequences of noncompliance. While many RUs are actively involved in community-based programs hosted by environmental authorities like CONANP or local CSOs working in the region, many are still misinformed about the boundaries of current NTAs in their region and the restrictions around them. However, the value of NTAs for fisheries recovery seems to be increasingly recognized (Suárez-Castillo et al. 2017). Over two thirds of the direct users included in my study acknowledged the value of NTAs for species reproduction, higher abundances, and in general higher catches.

Previous studies have also shown how NPAs in the northern GOC are often used by fishing communities from all different communities within the region (e.g. 83 % of RBBACBS is used by six communities, 38 % of PNASL is used by five communities, and two communities use RBISPM), with some fishers even traveling long distances to reach the NPA (Moreno-Báez et al. 2012). While it is possible that local fishers who have preferential use of permitted fishing grounds within the NPA know the boundaries of the NTAs, fishers from outside communities may not. Not having enough information about existing NTAs shows a weakness in the relationship between the resource users and the potential support for a no-fishing restriction within NPAs (link 6), an interaction that is crucial for proper effectiveness of NTAs. Link 6 determines whether RUs can comply with regulations. Simply stated, resource users are unlikely to comply with regulations if they are not aware of the boundaries of NTAs.

With regards to noncompliance and apathy issues, even when RUs have a good understanding about the boundaries of NTAs, they can easily choose not to comply with the restrictions of no-fishing inside the NTA. Reasons for noncompliance may include a lack of other employment alternatives (the most commonly cited response by RUs when asked if they had other livelihood alternatives besides fishing), skepticism about whether NTAs can work in providing them with benefits in the short or long term, or the fear that others will free ride on the efforts of a few to comply and will this take advantage of the situation. Although varied by NTA, my results shows high levels of perceived non-compliance behavior among RUs, even from the local public infrastructure provider perspective. This also represents a weakness in link 6 as groups of fishers become divided in their expectations on what NTAs can accomplish and comply accordingly with

NTAs, which can lead to conflict between complying and non-complying groups, or they all adopt non-complying behaviors.

Recent studies have hypothesized that the problem with noncompliance begins with the complicated division of monitoring and enforcement responsibilities among the appropriate federal agencies, which undermines their ability to properly ensure compliance (Rife et al. 2013). However, while most respondents in my study indeed had a perception that there is a lack of monitoring and enforcement by formal authorities in the region, I also show that the practice of reporting non-compliance activity to the appropriate federal authorities is also not prevalent in the region since most fishers opt for talking about it or doing nothing rather than reporting it (Figure 4). Furthermore, my results also show a lack of belief in the system and the perception that corruption is constantly present when it comes to proper monitoring and sanctioning of NTA restrictions, thus leading to a culture of apathy towards both complying with NTA regulations and reporting noncompliance of others (a weakness in link 6). While understaffing and underfunding on the PIPs side are real issues (a weakness in link 3), there is little that can be done to increase efforts for monitoring and enforcement mechanisms via the federal government and PIPs are already operating at capacity. Moreover, strengthening link 3 may not necessarily contribute to solving noncompliance issues unless the RUs perceive a change in the perception of *corruption* and noncompliance that has permeated the system, or unless the prospect of alternative livelihoods provides fishers with other choices that allows them to comply with regulations without affecting their livelihoods.

The negative perceptions towards the monitoring and sanctioning systems for NTAs sometimes change when RUs are actively engaged in the process of monitoring and sanctioning. In some communities (e.g. Bahía de los Ángeles), community-based surveillance groups have proved successful for certain periods of time (i.e. the RUs become PIPs by being agents of monitoring and enforcement of regulations). These programs, however, should be carefully implemented and on a voluntary basis rather than as subsidies programs for them to remain effective and functioning in the long-term and without the need of continuous funding to keep the programs running. The attributes of the community (e.g. community-dynamics, historical context, and social conflict) should also be carefully considered though since some communities may have different levels of conflict with other communities in the region that would undermine the operation of these programs.

Finally, the difference in perceptions between RUs and PIPs with respect to how NTAs have been successful and what the best way to implement them has been a significant setback for NTAs in the region. Since NTAs have only been established as NPAs managed by CONANP in the MIR, most RUs associate them with the concepts of conservation and preservation of ecosystems and threatened species. Our results also show how the current NPAs are perceived to be more successful for the purposes of conservation of biodiversity than for fisheries management (a weakness in link 6 if NTAs are to be employed as a strong fisheries management tool). The increased skepticism towards the success of current NPAs for fisheries management by the CSOs echoes a reflection on the history of planning efforts and management actions that have taken place in the region without many tangible outcomes, whereas the rest of the PIPs tend to base their perceptions on a shifting baseline.

We find that there is little collaboration between the different conservation and fisheries management PIPs due their seemingly opposing mission statements (i.e. SEMARNAT's mission is to protect and conserve biodiversity and marine resources, whereas SAGARPA's mission is to support the development of harvesting, albeit through sustainable practices). The need for collaboration platforms and strategies between the relevant PIPs become even more relevant for the appropriate implementation of the higher-level mandates to local-level management actions. Consequently, new routes and strategies for the establishment of new NTA networks are currently being proposed by CSOs and supported by larger FDNs and federal PIPs (including CONANP and CONAPESCA) that involve an inclusive, transparent, and participative process through the recognition of all stakeholder (i.e. RUs and PIPs) positions towards NTAs, the adoption of strategies to increase stakeholder buy-in for the NTAs (coming from the stakeholders themselves), and the incorporation of the SSF sector's input towards the design and planning of future NTAs (Suárez-Castillo et al. 2017).

Different NTA-type tools represent different types of soft human-made public infrastructure, each with its own set of processes, rules, and responsible parties. While VMRs were often preferred over all other NTA tools, FRZs were the second most popular choice, which shows a great deal of interest for this new policy for establishment of NTAs managed by CONAPESCA. VMRs have had significant failures in other regions of the GOC in the past due to the lack of formal recognition from the federal authorities (e.g. San Jorge Island as part of a community-based network of reserves in

Puerto Peñasco, which although an initial success, unachieved expectations and changing directorship of local fisheries offices led to its dissolution to avoid free-riding problems (Cudney-Bueno et al. 2009). However, the example of a voluntarily-proposed FRZ in the village of Puerto Libertad showed how a bottom-up process involving local SSF of all different types of organizations (e.g. independent fishers and cooperatives) can bring about positive social interactions and strong support for the establishment of NTAs for fisheries management (Espinosa-Romero and Torre 2012, Espinosa-Romero et al. 2014).

VMRs seem like a good way to begin the process of community-participation in the establishment of a NTA, although we recommend that the non-governmental PIPs aiding these efforts (e.g. CSOs working with the communities) seek the federal recognition of these areas via FRZs or NPAs (or extensions of NPAs to include NTAs). This would improve the credibility and acceptance of the NTA as well as the operational capacity of its management. Furthermore, we urge PIPs to carefully consider the governance context and history of the region where NTAs are being proposed (e.g. are the fishers formally organized into cooperatives or fishing committees vs. mostly independent fishers; have the communities had good experiences and involved participation in previous NTA efforts; is there trust between RUs and local PIPs working in the region, etc.) to identify the most appropriate NTA-type tool for each specific region. In other words, the choice of which type of soft public infrastructure will be more effective on the long-run highly depends on the careful consideration of the history of the region, the attributes of the community, the interactions between the different actors in the system (link 2) and the characteristics of the NTA-type tool being proposed.

Furthermore, close attention to the relationship between RUs and PIPs (link 2) would ensure that trust issues do not become a problem on the long-run, that there is sufficient and constructive communication between the two groups, and that collaboration and cooperation between and among RUs and PIPs happens in a conducive manner towards the successful establishment and subsequent functioning of the NTA. Timelines and continued engagement with the communities and all the relevant stakeholders are critical for the success of future NTAs. Past exercises that have attempted to establish NTAs in the MIR or elsewhere in the GOC have struggled to maintain the stakeholders and RUs engaged in the process to establish NTAs (a weakening of link 6) when it becomes too lengthy, which consequently can undermine the prospects for the acceptance of the NTA within the fishing community (pers. comm.). As shown in my results most stakeholders expect the process of NTA establishment to delay for no more than five years, on average, in order to ensure the expectations are met and that the establishment of NTAs remains relevant in the face of ongoing resource overexploitation problems. Furthermore, my study recognizes the need to develop parallel strategies to implement alternative livelihood programs that can mitigate the negative impact on SSF communities' livelihoods, and environmental education programs to strengthen knowledge about and support for NTAs at a local scale and increase stakeholder participation throughout the process (Bennett and Dearden 2014, Suárez-Castillo et al. 2017). Ultimately, important weaknesses in link 6, which are sometimes affected by weaknesses in link 2 and poor collaboration of PIPs, are what influence the ways that the soft infrastructure tools like NTAs affect the way in which the resource users interact with the resource (link 5).

3.5 Conclusion

This study elucidates how incorporating the current level of stakeholder understanding and support for the use of NTAs into the establishment and management processes of NTAs is a crucial strategy for both biodiversity conservation and fisheries management in the MIR, highlighting important weaknesses in the way in which NTAs have operated in the region. My results suggest mechanisms for improvement of NTA effectiveness by taking a closer look at some of these caveats and how they impact the dynamics of the whole SES from a governance perspective.

The shortcomings of current NTAs in the region occur due to major differences in levels of knowledge from the RUs and of perceptions between RUs and PIPs towards NTAs as tools for fisheries recovery zones, which is further hampered by a culture of apathy towards such management tools given the problems of corruption and free riding. In order for future NTAs to effectively succeed as fisheries recovery zones, I propose a careful consideration of specific NTA-type tools available within the Mexican context, such as VMRs, as an initial step towards the formal implementation of legal NTA-type tools. In this manner, RUs can have a first-hand experience with how NTAs work and why they are necessary, and potentially affecting their perceptions and subsequent support for these tools. I expect this analysis to set the stage for assessing putative management actions specific for each type of tool that can be applied as NTAs in the MIR as well as the rest of the GOC. Collectively, this work demonstrates ways to incorporate appropriate contextual social, and governance characteristics into their planning processes to improve stakeholder response to these tools and policies.

3.6 References

Álvarez-Romero, J. G., R. L. Pressey, N. C. Ban, J. Torre-Cosio, and O. Aburto-Oropeza. 2013. Marine conservation planning in practice: lessons learned from the Gulf of California. Aquatic Conservation: Marine and freshwater ecosystems **23**:483-505.

Anderies, J. M. 2015. Understanding the Dynamics of Sustainable Social-Ecological Systems: Human Behavior, Institutions, and Regulatory Feedback Networks Bulletin of Mathematical Biology **77**:259-280.

Anderies, J. M., and M. A. Janssen. 2013. Robustness of Social-Ecological-Systems: Implications for public policy Policy Studies Journal **41**:513-536.

Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. A framework to analyse the robustness of Social-Ecological-Systems from an institutional perspective. Ecology and Society **9**:18.

Ayala-Bocos, A., H. Reyes-Bonilla, L. E. Calderón-Aguilera, M. D. Herrero-Perezrul, and P. C. González-Espinosa. 2016. Forecasting changes in sea surface temperature in the Gulf of California, and theirs effects on abundance and distribution of reef species. Revista Ciencias Marinas y Costeras **8**:29 - 40.

Basurto, X., L. Bourillon, and J. Torre. 2000. The role of a Non-Governmental Organization (NGO) in an emerging co-management regime: the Mexican Seri Indians' case study. Proceedings of the 8th Biennial conference of the International Association for Study of Common Property (IASCP):26.

Basurto, X., A. Cinti, L. Bourillon, M. Rojo, J. Torre-Cosio, and A. Hudson Weaver. 2012. The emergence of access controls in small-scale fishing commons: A comparative analysis of individual licenses and common property-rights in two mexican communities. Human Ecology **40**:597-609.

Basurto, X., and E. Coleman. 2010. Institutional and ecological interplay for successful self-governance of community-based fisheries. Ecological Economics **69**:1094-1103.

Becker, C. D., and E. Ostrom. 1995. Human ecology and resource sustainability: the importance of institutional diversity. Annual Review of Ecology and Systematics **26**:113-133.

Bennett, N. J., and P. Dearden. 2014. From measuring outcomes to providing inputs: governance, management, and local development for more effective marine protected areas. Marine Policy **50**:96 - 110.

Bourillon, L., and J. Torre. 2012. Areas marinas protegidas del Golfo de California para mitigar los efectos de la pesca de arrastre en la biodiversidad: Limitaciones y propuesta de nuevo enfoque. Pages 399 - 411 *in* J. Lopez-Martinez and E. Morales-bojorquez, editors. Efectos de la pesca de arrastre en el Golfo de California. Centro de Investifaciones Biologicas del Noroeste, S.C. y Fundacion Produce Sonora, Mexico.

Brusca, R., L. T. Findley, P. Hastings, M. E. Hendrickx, J. Torre Cosio, and A. M. van der Heiden. 2005. Macrofaunal biodiversity in the Gulf of California. Pages 179 - 203 *in* J. L. E. Cartron, G. Ceballos, and R. S. Felger, editors. Biodiversity, Ecosystems, and Conservation in Northern Mexico. Oxford University Press, New Yotk.

Carvajal, M. A., A. Robles, and E. Ezcurra. 2010. Ecological conservation in the Gulf of California. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

CEMDA, and COBI. 2010. Implementacion de Reservas Marinas en Mexico.

Cinti, A., J. N. Duberstein, E. Torreblanca, and M. Moreno-Baez. 2014. Overfishign drivers and opportuities for recovery in small-scale fisheries of the Midriff Islands Region, Gulf of California, Mexico: the roles of land and sea institutions in fisheries sustainability. Ecology and Society **19**:15.

Cinti, A., W. Shaw, R. Cudney-Bueno, and M. Rojo. 2010a. The unintended consequences of formal fisheries policies: Social disparities and resource overuse in a major fishing community in the Gulf of California, Mexico. Marine Policy **34**:328-339.

Cinti, A., W. W. Shaw, and J. Torre. 2010b. Insights from the users to imrpove fisheries performance: Fisher's knowledge and attitudes on fisheries policie sin Bahia de Kino, Gulf of California, Mexico. Marine Policy **34**:1322-1334.

Cisneros-Mata, M. A. 2010. The importance of fisheries in the Gulf of California and ecosystem-based sustainable co-management for conservation. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Cisneros-Mata, M. A., M. J. Espinosa-Romero, E. A. Ramírez-Félix, V. I. González-Gallardo, C. Gómez-Rojo, and J. Torre. 2014. Proceso de elaboración y resultados preliminares del Plan de Manejo para las Pesquerías de Jaiba en Sinaloa y Sonora. Informe de Investigación. . DGIPN.

Cisneros-Montemayor, A. M., M. A. Cisneros-Mata, S. Harper, and D. Pauly. 2013. Extent and implications of IUU catch in Mexico's marine fisheries. Marine Policy **39**:283-288.

CONABIO, CONANP, TNC, and PRONATURA. 2007. Analisis de vacios y omisiones en conservacion de la biodiversidad marina en Mexico: Oceanos, costas e islas. Mexico, D.F.

Cudney-Bueno, R., L. Bourillo, A. Saenz-Arroyo, J. Torre-Cosio, P. Turk-Boyer, and W. W. Shaw. 2009. Governance and effects of marine reserves in the Gulf of California, Mexico. Ocean & Coastal Management **52**:207-218.

Díaz-Uribe, J. G., F. Arreguín-Sánchez, D. Lercari-Bernier, V. H. Cruz-Escalona, M. J. Zetina-Rejón, P. del-Monte-Luna, and S. Martínez-Aguilar. 2012. An integrated ecosystem trophic model for the North and Central Gulf of California: An alternative view for endemic species conservation. Ecological Modelling **230**:73–91.

DOF. 2014. NOM-049-SAG/PESC-2014, Que determina el procedimiento para establecer zonas de refugio para los recursos pesqueros en aguas de jurisdicción federal de los Estados Unidos Mexicanos. .

Espinosa-Romero, M. J., A. A. Rodriguez, A. Hudson Weaver, C. Villanueva-Aznar, and J. Torre. 2014. The changing role of NGOs in Mexican small-scale fisheries: From environmental conservation to multi-scale governance. Marine Policy **50**:290 - 299.

Espinosa-Romero, M. J., and J. Torre. 2012. Implementando el enfoque ecosistémico al manejo pesquero. Caso de Estudio: Puerto Libertad, Sonora. .

Ferse, S. C. A., M. Mañez Costa, K. Schwerdtner Mañez, D. S. Adhuri, and M. Glaser. 2010. Allies, not aliens: increasing the role of local communities in marine protected area implementation. Environmental Conservation **37**:23-34.

Fraschetti, A., J. Claudet, and K. Grorud-Colvert. 2011. Management - Transitioning from single-sector management to ecosystem-based management: What can marine protected areas offer?*in* J. Claudet, editor. Marine Protected Areas, A Multidisciplinary Approach. Cambridge University Press, New York, USA.

Fujitani, M. L., E. P. Fenichel, J. Torre, and L. R. Gerber. 2012. Implementation of a marine reserve has a rapid but short-lived effect on recreational angler use. Ecological Applications **22**:597-605.

García-Hernández, J., M. J. Espinosa-Romero, M. A. Cisneros-Mata, G. Leyva-García, D. Aguilera-Márquez, and J. Torre Cosio. 2015. Concentración de mercurio y plaguicidas organoclorados (poc) en tejido comestible de jaiba café *Callinectes bellicosus* de las costas de Sonora y Sinaloa, México. Ciencia Pesquera **23**:65 - 79.

Herman, H. 2004. El papel de las organizaciones de la sociedad civil en el manejo costero en México. Pages 115–132 *in* Rivera-Arriaga, Villalobos-Zapata, Azuz-Adeath, and Rosado-May, editors. El manejo costero en México.

Hilborn, R., K. Stokes, J. J. Maguire, T. Smith, L. W. Botsford, M. Mangel, J. Orensanz, A. Parma, J. Rice, J. Bell, K. L. Cochrane, S. Garcia, S. J. Hall, G. P. Kirkwood, K. Sainsbury, G. Stefansson, and C. Walters. 2004. When can marine reserves improve fisheries management? Ocean & Coastal Management **47**:197–205.

INEGI. 2010. Censo de Poblacion y Vivienda.

Jones, P. J. S. 2014. Governing Marine Protected Areas: Resilience through diversity. Routledge, Oxon, UK.

Lluch-Cota, S. E., E. A. Aragon-Noriega, F. Arreguin-Sanchez, D. Aurioles-Gamboa, J. J. Bautista-Romero, R. C. Brusca, R. Cervantes-Duarte, R. Cortes-Altamirano, P. Del-Monte-Luna, A. Esquivel-Herrera, G. Fernandez, M. E. Hendrickx, S. Hernandez-Vazquez, H. Herrera-Cervantes, M. Kahru, M. Lavin, D. Lluch-Belda, D. B. Lluch-Cota, J. Lopez-Martinez, S. G. Marinone, M. O. Nevarez-Martinez, S. Ortega-Garcia, E. Palacios-Castro, A. Pares-Sierra, G. Ponce-Diaz, M. Ramirez-Rodriguez, C. A. Salinas-Zavala, R. A. Schwartzlose, and A. P. Sierra-Beltran. 2007. The Gulf of California: Review of ecosystem status and sustainability challenges. Progress In Oceanography **73**:1-26.

Lundquist, C. J., and E. F. Granek. 2005. Strategies for successful marine conservation: integrating socioeconomic, political, and scientific factors. Conservation Biology **19**:1771-1778.

Mancha-Cisneros, M. M., and L. R. Gerber. 2015. Guiding principles for green economic development in the marine environment: Insights from small-scale fisheries and marine protected areas.*in* A. Gasparatos and K. J. Willis, editors. Biodiversity in the Green Economy. Routledge, London, U.K.

Meza-Monge, A., M. J. Espinosa-Romero, and J. Torre-Cosio. 2015. Difundiendo los instrumentos legales para el aprovechamiento sustentable de la jaiba en Sonora, México. Ciencia Pesquera **23**:91 - 100.

Micheli, F., A. Saenz-Arroyo, A. Greenley, L. Vazquez, J. A. Espinoza Montes, M. Rossetto, and G. A. De Leo. 2012. Evidence that marine reserves enhance resilience to climatic impacts. PLoS ONE **7** e40832.

Moreno-Báez, M., R. Cudney-Bueno, B. J. Orr, W. W. Shaw, T. Pfister, J. Torre-Cosio, R. Loaiza, and M. Rojo. 2012. Integrating the spatial and temporal dimensions of fishing activities for management in the Northern Gulf of California, Mexico. Ocean and Coastal Management **55**:111-127.

Morzaria-Luna, H. 2016. Determinación de la extensión y situación actual de reservas marinas en la Región de las Grandes Islas (RGI) y Norte del Golfo de California para reducir los efectos del cambio climático en la producción pesquera y la función del ecosistema. Tucson, AZ.

Ostrom, E. 1990. Governing the commons: The evolution of institutions for collective action. Cambridge University Press, Cambridge.

Ostrom, E. 2011. Background on the Institutional Analysis and Development Framework. Policy Studies Journal **39**:7-27.

Pollnac, R., P. Christie, J. E. Cinner, T. Dalton, T. M. Daw, G. E. Forrester, N. A. J. Graham, and T. R. McClanahan. 2010. Marine reserves as linked social-ecological systems. Proceedings of the National Academy of Sciences **107**:18262-18265.

Poteete, A. R., M. A. Janssen, and E. Ostrom. 2010. Working together: Collective action, the commons, and multiple methods in practice. Princeton University Press Princeton, New Jersey.

Précoma de la Mora, M. 2015. Distribución potencial de peces de importancia comercial en el norte del Golfo de California, México: influencia del cambio climático sobre las principales áreas de pesca de la zona. , Ensenada, Baja California, México.

Revollo-Fernández, D. A. 2012 Eficiencia técnica, social y económica de la pesquería de abulón bajo un esquema de gestión por medio de reservas marinas: el caso de Isla Natividad, Baja California. Universidad Nacional Autónoma de México, México, D.F. .

Rife, A. N., B. Erisman, A. Sanchez, and O. Aburto-Oropeza. 2013. When good intentions are not enough...Insights on networks of "paper park" marine protected areas. Conservation Letters **6**:200-212.

Sale, P. F., R. K. Cowen, B. S. Danilowicz, G. P. Jones, J. P. Kritzer, K. C. Lindeman, S. Planes, N. V. C. Polunin, G. R. Russ, Y. J. Sadovy, and R. S. Steneck. 2005. Critical science gaps impede use of no-take fishery reserves. TRENDS in Ecology and Evolution **20**:74-80.

Suárez-Castillo, A. N., J. Torre, M. J. Espinosa-Romero, M. M. Mancha-Cisneros, and J. G. Alvarez-Romero. 2017. Ruta de Sociabilización para integrar al sector productivo en una propuesta de red de zonas de recuperación pesquera en la región de las Grandes Islas, Golfo de California. Ciencia Pesquera ***in press***.

Torre, J., E. Rolón, M. J. Espinosa-Romero, and S. Fulton. 2016. Zonas de recuperación marina como herramientas de conservación y pesca sustentable en México.*in* Biodiversidad, editor. Análisis y propuestas para la conservación de la biodiversidad en México.

Ulloa, R., J. Torre, L. Bourillon, A. Gonder, and N. Alcantar. 2007. Planeacion para la conservacion marina: Golfo de California y costa occidental de Baja California Sur. Comunidad y Biodiversidad, A.C., Guaymas, Mexico.

White, A., and C. A. Courtney, editors. 2004. Policy instruments for coral reef management and their effectiveness. 2nd edition. World Fish Center Conference Proceedings.

Zepeda-Domínguez, J. A., M. J. Zetina-Rejón, A. Espinoza-Tenorio, G. Ponce-Díaz, D. Lluch-Belda, M. J. Espinosa-Romero, J. Torre-Cosio, and M. A. Cisneros-Mata. 2015. Mapeo topológico de los actores involucrados en el manejo de la pesquería de jaiba café *Callinectes bellicosus* en Sonora, México. Ciencia Pesquera **23**:81 - 90.

CHAPTER 4

INTEGRATING STAKEHOLDER AND SCIENCE-BASED APPROACHES TO NO-TAKE AREA DESIGN IN THE GULF OF CALIFORNIA, MEXICO

4.1 Introduction

Marine protected areas (MPAs) have become a widely-used approach in the sustainable management of marine fisheries (Fraschetti et al. 2011). However, no-take areas (NTAs) are often framed as a conflict between conservation and fishing objectives. A significant challenge in fisheries management is ensuring job security for fishers while also sustainably managing their fishing resources. Even though long-term benefits of stock recovery within and adjacent to NTAs has been demonstrated (Micheli et al. 2004), short-term costs are often argued as opposition to NTAs. In many cases, limited success of certain NTAs can be attributed to the lack of attention to stakeholder interests and human capacity building (Gill et al. 2017), as well as the socio-economic context (McClanahan 1999, Christie et al. 2003, Christie 2004, Cinner 2007) into the planning and management of NTAs. In this chapter, I demonstrate a process for stakeholder engagement in spatial conservation planning to show that fisher preferences can complement rather than compromise proposed NTA network solutions with minimal increases to size and cost.

The systematic conservation planning (SCP) framework represents a practical and effective way to design NTAs by identifying areas for effective conservation actions while minimizing costs (Pressey and Bottril 2009, Álvarez-Romero et al. 2013). Incorporating socioeconomic criteria, such as single-species fishing data, fine-scale commercial fishing data, and even confidential sensitive commercial fishing data) for

NTA selection without compromising ecological goals using numerical optimization tools has been shown to produce networks of NTAs that reduce economic losses incurred by fishers (Richardson et al. 2006) while only slightly increasing their size compared to networks designed without consideration of commercial data (Stewart and Possingham 2005), and resembling, or even exceeding, desired habitat representation with less impact on commercial and recreational fisheries than those devised by purely stakeholder-driven processes (Klein et al. 2008).

An important step within the SCP framework is the identification and involvement of stakeholders, including affected fisher communities (Pressey and Bottril 2009), which can occur at various stages throughout the planning and implementation process. On one end of the spectrum, stakeholder-based planning approaches ensure early participation of key stakeholder groups to provide key input in the design of the network. Most successful examples of this approach occur at small regional scales and for the implementation of single NTAs that can then scale-up to regional networks (White et al. 2002). Stakeholder-based approaches have also been favoured especially in data-poor regions where local knowledge can be very valuable to the process of selecting relevant areas for conservation (Ban et al. 2009a).

In contrast, science-based approaches seek to identify priority areas as part of the NTA network through a scientific design process and then engage with local communities to assess or improve network designs. This approach is often desirable in situations where there is concern for initially raising unreasonable expectations beyond the capacity to carry out the planning efforts, there is a strong interest in pursuing robust technical design approaches that may not make it practical to engage with community members, or spatial and socio-cultural scale of stakeholder groups becomes too large to reasonably involve all interested parties, (Green et al. 2009). However, this approach requires significant investment in acquiring reliable, spatial data of every element going into the design process (e.g. biodiversity features, socioeconomic costs, etc.) (Ban et al. 2009b), especially when used over large spatial planning regions (Gleason et al. 2010).

In practice, most efforts result in a combination of science-based approaches incorporating a variety of tools and data sources, along with available opportunities for NTA network establishment facilitated by political will and stakeholder coordination. Studies where both science-based and stakeholder-based approaches are integrated (Ban et al. 2009b, Ruiz-Frau et al. 2015) using numerical optimization tools like Marxan (Ball et al. 2009) demonstrate how a more integrated approach can serve biodiversity conservation objectives while achieving community acceptance, thus leading to more effective conservation outcomes. However, the biophysical and ecological integrity of NTA network designs must be maintained throughout integration so that both conservation and socioeconomic objectives are efficiently met.

Building on previous work in Canada and the U.K. (Ban et al. (2009b), Ruiz-Frau et al. (2015)), I developed an integrated stakeholder-based and science-based approach for NTA design. With the Gulf of California, Mexico as a case study, I demonstrate a planning process to establish NTA network designs that incorporate stakeholder preferences while also achieving conservation objectives at low cost. My approach differs from previous work in that I integrate both approaches by constraining the selection of NTAs with areas that were heavily selected through both the stakeholder-based and science-based approaches. I first compare NTAs identified through a science-based approach (biophysical and economic information) with those identified through a stakeholder-based approach (stakeholder preferences). I then develop a network design that includes biologically-relevant hotspots, minimal opportunity cost to fishers, and socially-preferred NTAs of the network.

4.2 Methods

I followed a three-step methodology to designing networks of NTAs based on science-based and stakeholder-based approaches, both together and separately (Table 4.1). First, the science-based approach followed the methodology outlined in (Álvarez-Romero et al. *in review*) through a systematic conservation planning framework with the goal of designing a network of NTAs that represents biodiversity of fish and invertebrate commercial species and their associated habitats while minimizing costs to fishers. Second, I developed a stakeholder-based approach to design a network of NTAs by undertaking a participatory mapping exercise to gather information on local fisher knowledge and preferences for placement of NTAs within my study area. Finally, I further explore these fisher-driven selection methods to incorporate their preferences for NTA placement into the science-based prioritization effort to develop a science-stakeholder agreement approach to designing networks of NTAs in the GOC.

Table 4.1. Summary of prioritization scenarios.

Solution	Scenario	Description	Features included
A1	Science-based approach	Goal of protecting areas important to safeguard ecosystems and species of conservation and commercial value using Marxan	Rocky-reef associated: • Ecosystems (6 types) • Species (103 fish, 87 invertebrates) • Spawning areas (10 species)
A2	Stakeholder-based approach	Same as A1 but through a participatory mapping process	Local user knowledge on location of reef-associated: • Ecosystems • Species • Spawning areas
A3	Science-stakeholder agreement approach	Same as A1, using Marxan but constraining output solutions with stakeholder preferences from S2.	Same as A1 and A2

4.2.1 Study Area

My study area is in the Midriff Islands region (MRI), which harbors 45 islands and islets of high levels of endemicity, biodiversity and biological productivity in terms of fisheries (Alvarez-Borrego 2007). The planning domain corresponded to the Midriff Islands Marine Priority Area (CONABIO et al. 2007), and was defined according to a combination of criteria, including its recognition as an important marine ecoregion and the bathymetry relevant to the distribution of rocky reef ecosystems (where most small-scale fishing occurs) and their associated species and habitats. The MRI currently encompasses three individually-managed MPAs (Figure 4.1), each with their own set of NTAs within the MPA (Figure 4.2, Table 4.2).

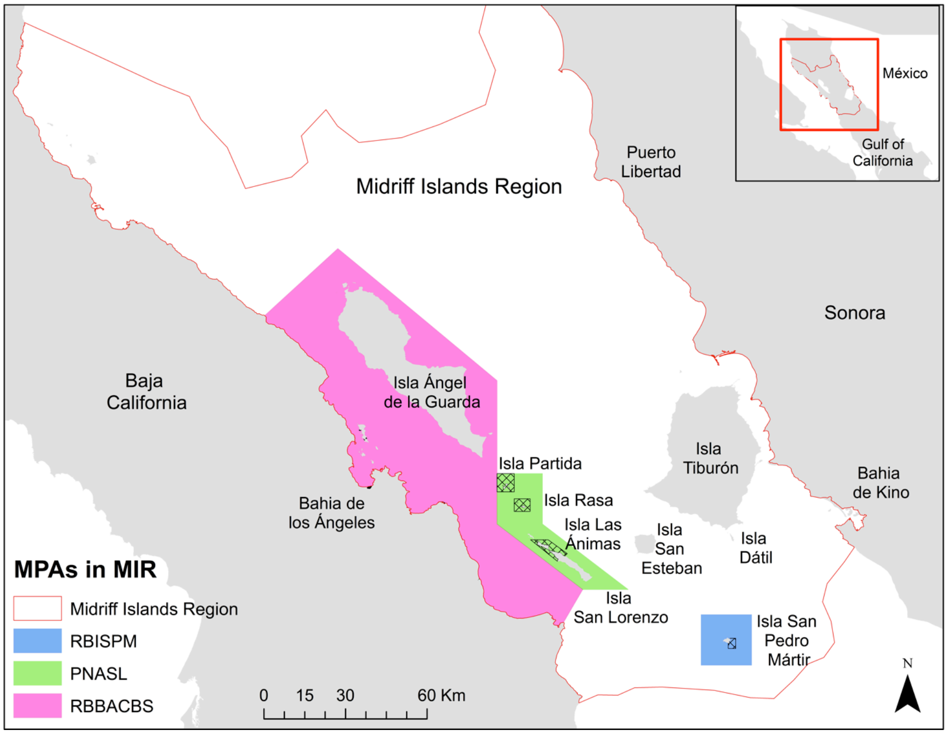

Figure 4.1. Planning domain boundaries and current Natural (Marine) Protected Areas within the study area.

Table 4.2. Current MPAs and their NTAs in the MRI. RBISPM = RB Isla San Pedro Mártir, PNASL = PN Archipielago de San Lorenzo, RBBACBS = RB Bahía de los Ángeles Canal de Ballenas y Salsipuedes.

	MPA	NTA	
Name (year decreed)	*Area (km²)*	*km²*	*%*
RBISPM (2002)	*298.76*	*8.21*	*2.75*
Protection subzone		8.25	100.00
PNASL (2005)	*584.42*	*88.05*	*15.07*
Partido-Partida		36.01	40.99
Rasito-Rasa		23.23	26.44
Animas-San Lorenzo		28.61	32.57
RBBACBS (2007)	*3,879.57*	*2.07*	*0.05*
Campo Polilla		0.23	10.04
Esteros de las Cahuamas Este		0.18	7.86
Esteros de las Cahuamas Oeste		0.15	6.55
Estero La Mona		1.07	46.72
Ensenada Los Choros		0.58	25.33
Estero San Rafael		0.08	3.49
TOTAL	4,762.75	98.33	2.06

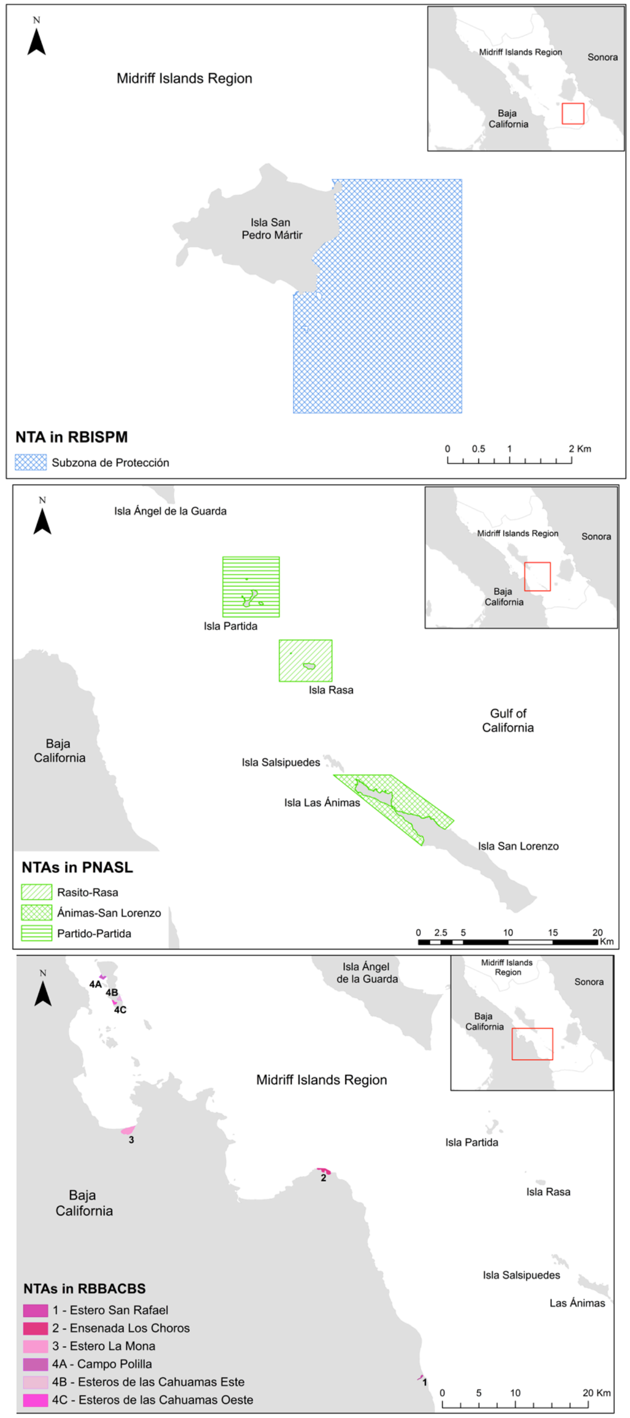

Figure 4.2. Existing NTAs within the MPAs in the MRI region: RB Isla San Pedro Mártir (*top*), PN Archipielago de San Lorenzo (*center*), and RB Bahía de los Ángeles Canal de Ballenas y Salsipuedes (*bottom*).

4.2.2 Prioritizing NTAs with incorporation of stakeholder preferences

4.2.2.1 Science-based approach

I focused my analysis on rocky reef-associated species, which have high socioeconomic and ecological importance in the region (Moreno-Báez et al. 2012), as well as other ecosystems important for providing feeding, reproductive, and spawning habitat for these species during different life stages. Four types of conservation features were selected, including 190 species (103 fish, 87 invertebrates), 6 habitats (rocky reefs, mangroves, seagrass meadows, *Sargassum* beds, coastal wetlands, and rhodolith beds), and 10 spawning sites (4 fish species and 6 invertebrate species). Spatial information on all 190 species came from species distribution models generated with MaxEnt (Elith et al. 2011) using occurrence records and 21 environmental parameters known to affect species distribution to predict climatic suitability and establish species coverage within the planning domain (these predictions were then corroborated by experts' empirical knowledge). Spatial data on habitats and spawning aggregations came from existing planning exercises, previous studies, underwater censuses, satellite imagery, and local user information (see Álvarez-Romero et al. (*in review*) for detailed information regarding the spatial prioritization). Migratory and wide-ranging species (e.g. pelagic fish, marine mammals, sea turtles, seabirds) were excluded from my study given the different management strategies that they require (Anadon et al. 2011).

To account for the potential economic loss to fishers associated with the exclusion of fishing activities within the NTA network, an 'opportunity cost' layer was estimated (following Adams et al. (2011)) as a function of targeted species biomass, potential catch by different fishing fleets (26 operating in the region), and market value of targeted species (based on interviews with fishers (Suárez-Castillo 2014) and published data (CONAPESCA 2011)). Opportunity cost was calculated based on the Atlantis framework for the northern GOC (Ainsworth et al. 2011), a spatially-explicit ecosystem model framework simulating ecosystem dynamics (including fisheries activities). Opportunity cost was estimated per fleet (including small-scale, industrial, and recreational fishing fleets) based on a one-year forward simulation under modelled 2008 fishing mortality, predicted biomass, and percentage catch of each species per fleet. Distance to nearby ports was not incorporated into the opportunity cost calculations. Total opportunity cost (in Thousands of Mexican Pesos) was then obtained by summing opportunity cost across all fleets, scaling down to each planning unit, and weighted uniformly (given the lack of reliable information on number of fishers per fleet) (see Álvarez-Romero et al. (*in review*) for detailed information regarding the opportunity cost estimation and downscaling).

Alternative networks of NTAs containing a selection of areas that achieve a set of conservation objectives whilst minimizing opportunity costs to fishers were generated using the decision-support tool Marxan (Ball et al. 2009). I used 1 km^2 hexagonal planning units (n=11,097) covering marine areas and coastal features ecologically linked to rocky reefs below and including the 200m depth isobath. Marxan was run 100 times with 1,000,000 iterations each. The targets for the protection of each conservation feature incorporated information on threat and rarity scores, and ranged between 11 – 90% of desired protection for the selected habitats, between 0.6 – 43.5% for fish species, between 0.5 – 21% for invertebrates, and between 68 – 100% for spawning aggregation sites (Table 4.3, see Álvarez-Romero et al. (*in review*) for more details how conservation objectives were calculated). Spawning and rhodolith sites were represented as individual locations, with 68 spawning sites and 19 rhodolith sites in total within the MIR.

Table 4.3. Overall conservation objectives for all six habitats and sites identified as important for spawning aggregations. The number next to each habitat represents the number of individual features for each habitat, which vary based on location, and each individual feature held its own conservation objective (see Table B1 in Appendix B).

Conservation feature	Total area in MIR (km^2)	Overall objective (%)
Mangrove (2)	25.2	9.2
Rocky reef (5)	74.8	7.7
Sargassum forests (4)	13.3	9.8
Seagrass beds (2)	88.1	5.4
Wetland (5)	80.9	9.7
Rhodolith sites (4)	0.6	29.2
Spawning sites (10)	17.4	30.5

4.2.2.2 *Stakeholder-based approach through participatory mapping exercises*

In order to collect spatially-explicit preferences by small-scale fishers, I conducted a series of structured interviews during the summer of 2015 to small-scale commercial fishermen from the communities of Bahía Kino (n=49), Puerto Libertad (n=25), and Bahía de los Ángeles (n=11). Respondents were given sub-sections of the study area indicating the spatial domain under consideration with the planning unit grid on each map. The interview implemented was also part of another study on the perceptions of different stakeholder groups with respect to the use of MPAs for conservation of biodiversity and management of fisheries in the region (Mancha-Cisneros et al. *in review*).

The spatially-explicit portion of the interview included three participatory mapping questions using the same spatial domain and planning unit grid used for the science-based approach. Out of the 124 fishermen, 87 responded to the spatially-explicit portion of the interview, which gives us a response ratio of 0.7. Respondents were asked: Within the spatial domain provided: (1) which areas did they consider most important for biodiversity conservation and fisheries management; (2) of those chosen in (1), which were considered in need of any sort of protection (e.g. seasonal closure, NTAs, gear restrictions); and (3) of those chosen in (2), which were considered necessary sites to be included as part of a network of NTAs. The purpose of the three-fold spatially-explicit approach was to obtain the smallest possible area in which fishers were willing to give up fishing, and to allow fishers to distinguish between what is important from a management perspective and what they are willing to comply with as a no-fishing area. For the purposes of this analysis, I utilized the responses from the (3) interview question as the main output for stakeholder-based preferences. The mapped output responses were then georeferenced, compiled and collated as a spatially-explicit dataset representing small-scale fisher preferences for placement of a network of NTAs and the selection frequency of each planning unit (i.e. how many times a planning unit was selected by fishers).

4.2.2.3Science-stakeholder agreement approach

Marxan provides a summed solution called “selection frequency map”, which corresponds to a spatial display of the number of times each planning unit has been selected amongst the ‘best’ solutions. Selection frequency thus summarizes which areas might have a higher priority for protection based on the features it contains to achieve the set objectives. These maps can also be interpreted as a measure of the likelihood that a given planning unit will be required/included in the system of NTAs. Higher values indicate high irreplaceability whereas lower-value areas represent areas that, although not necessarily unimportant, can more easily be replaced to achieve conservation objectives. The value of units with lower selection frequencies can change significantly if other units (e.g. currently identified as highly irreplaceable) become unavailable due to socioeconomic constraints or their ecological features are irreversibly or significantly affected by anthropogenic or natural causes.

To design a combined science-based and stakeholder-based approach, planning units most frequently selected by fishers in the stakholder-based approach that were also most frequently selected in the science-based approach were locked-in to generate new science-stakeholder agreement solutions. In other words, the most frequently selected planning units from both outputs were locked-in on Marxan so that they are automatically included in the 'best' solution for the integrated approach, thus constraining the science-based approach to also consider frequently-selected planning units by fishers that were also highly irreplaceable. My approach to achieving a science-stakeholder agreement solution comprised 3 steps: **(1)** isolating planning-unit selection frequency ranges from the science-based and stakeholder-based approaches separately; **(2)** re-running Marxan using both science-based and stakeholder-based outputs for each selection frequency range to obtain output solutions for the integrated approach; and **(3)** identifying a planning unit lock-in proportion by comparing Marxan's best solution outputs from the combined approach to the outputs from the science-based approach (Figure 4.3).

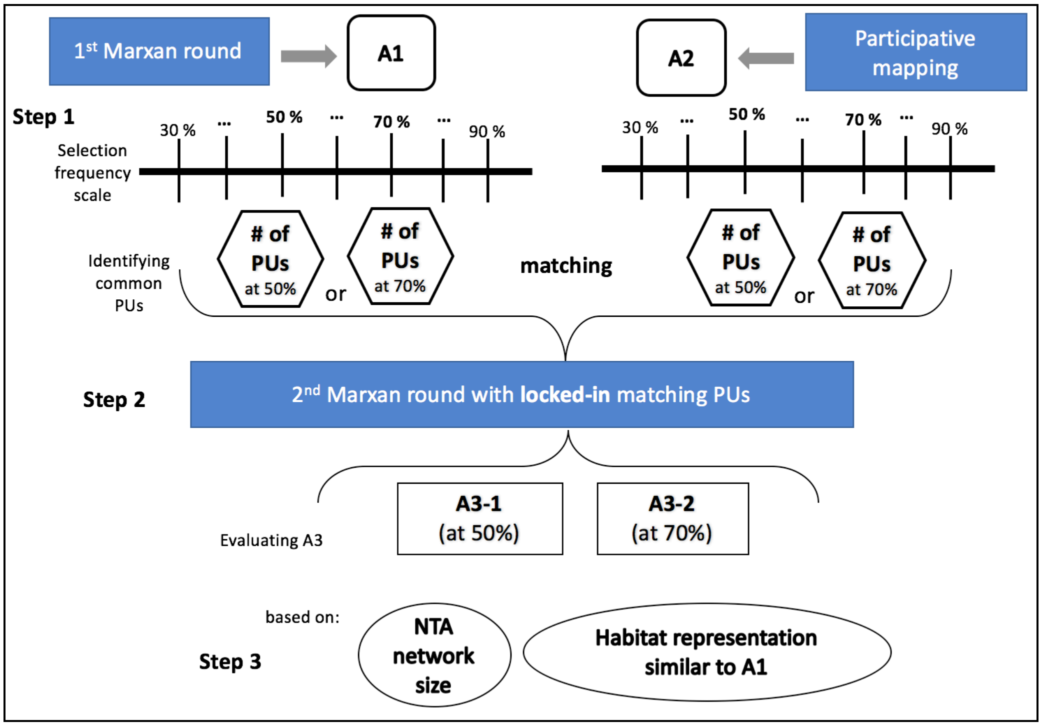

Figure 4.3. Procedure for achieving a science-stakeholder agreement solutions. An example for using the 50% and 70% selection frequency ranges is shown here, but the method applies to all selection frequency ranges between 30% and 100%. PU = Planning unit. A1 = Science-based; A2 = Stakeholder-based; A3 = Science-stakeholder agreement.

In Step **(1)**, I compared selection frequencies of fisher spatially-explicit preferences in the stakeholder-based output to the selection frequency output from the Marxan solutions in the science-based approach by first identifying planning units that were within specific selection frequency ranges in each approach (e.g. planning units that were selected between 30 and 100 times, or having above a 30% selection frequency), including 30, 40, 50, 60, 70, 80 and 90% selection frequencies), separately. As Ruiz-Frau et al. (2015), I considered areas with selection frequencies above 25 % as areas considered priority for conservation, hence areas below 30% were considered too low to be included in the analysis. In Step **(2)**, I ran Marxan while locking-in planning units that were selected at and above each of the selection frequency ranges for both the science-based and stakeholder-based approaches (i.e. I only locked-in planning units that were selected as at least as many times in the stakeholder-based approach as well as the science-based approach) to obtain the combined outputs. This step yielded seven science-based output solutions that were in a way constrained by stakeholder preferences. In Step **(3)** I identified a planning unit lock-in proportion for the combined approach by comparing the best solution outputs in terms of resulting number of NTAs, habitat representation within the network, and total area of the network.

My science-stakeholder agreement approach presents the novel quality of systematically incorporating stakeholder preferences into an optimization planning framework that ensures the selection of socially-accepted planning units for the NTA network by members of a representative sample of the small-scale fishing community that also contribute to a science-based solution for achieving all conservation targets.

4.2.3 Assessment of NTA networks under different approaches

In order to assess the differences between the science-based approach (A1) and the stakeholder-based approach (A2), I first compared the level of overlap in planning unit selection between the two selection frequency percentage maps by building a "Difference of agreement" map, and I then cross-compare it with habitat conservation features. The "Difference of agreement" map shows a Disagreement Index that was created by obtaining the difference between the stakeholder-based approach relative selection frequency output and the science-based selection frequency output. No single planning unit was selected by all 85 fishers interviewed, and the highest selected planning unit was one selected by only 19 fishers. Therefore, I used the relative selection frequency percentage for A2 in order to compare with the science-based approach selection frequency percentages (in which more than one planning unit was selected 100% of the time during Marxan runs).

I then compared the output best solutions for all three approaches in terms of achievement of conservation targets, size (i.e. total number of NTAs within the network), spatial coverage and habitat representation (i.e. percent of each habitat feature included in each solution), and total opportunity cost. I also compared the science-based output with the current network of existing MPAs and their respective NTAs to assess the current gaps for NTAs with the goal of improving fisheries management in the region.

4.3 Results

4.3.1 Identification of planning-unit lock-in proportion

Given the large size of the planning region of the MIR, and the high mobility of small-scale fishers in the communities of Bahía de Kino, and to a lesser extend Puerto Libertad (Moreno-Báez et al. 2012), the stakeholder-based approach yielded a widely-varied selection of areas for a NTA network design. Of the 11,097 1-km^2 planning units, 5,928 were chosen at least once by a small-scale fisher during the interviews (Figure B2 in Appendix). In contrast, the best solution map for the science-based approach included only 285 planning units clumped into a total of 70 patches (i.e. individual NTAs). To appropriately incorporate fisher preferences into the final network design and prevent easily replaceable planning units from being automatically included in the science-stakeholder agreement design, identifying an optimal lock-in proportion for the stakeholder-selected areas becomes necessary since not every planning unit is essential for a network that efficiently achieves conservation objectives and minimizes opportunity cost.

Sensitivity analyses of locking-in different selection frequency ranges within Marxan in Step 3 indicate that the combined approach (A3, Science-stakeholder agreement approach) was most similar to the science-based approach when I locked-in planning units that were above the 50% selection frequency in both A1 and A2. Out of the 5,928 planning units selected by fishers, 362 were selected by more than half the fishers in my sample, and seventeen of those 362 were also selected amongst Marxan's 'best' solutions more than 50% of the time. These seventeen planning units would be considered the most irreplaceable given that they were frequently selected by both Marxan (in A1) and stakeholders (in A2). Therefore, I present the results for the science-stakeholder agreement integrated approach (A3) when these 17 planning units were locked-in to develop the final solution.

4.3.2 Comparison of approaches

Given that both fish and invertebrate species coverage within the MIR was determined via species distribution modelling approaches throughout a large region rather than extensive on-site distribution assessments, I only present the results for how different approaches achieve habitat and spawning site conservation objectives (Table 4.3). Although assessing the percentage of species conservation features included in the selected solutions is beyond the scope of this study, both the science-based (A1) and science-stakeholder agreement (A3) approaches met all conservation objectives, including those for the 190 species.

The existing NTAs in the MIR are small in terms of total area and do not overlap by more than 60% with the science-based scenario (Table 4.4), especially with Parque Nacional Archipielago de San Lorenzo (PNASL, Figure 4.2b). Although these NTAs are permanently decreed, they were not initially designed with the same goals and methodology as my science-based or stakeholder-based approaches, nor did they incorporate extensive consideration of opportunity cost or other spatially-explicit socioeconomic impacts of the selected areas. Therefore, comparison of my results to existing NTAs should interpreted with caution.

Table 4.4. Existing NTAs' overlap with the science-based approach (A1) within the MRI.

Existing NTAs	RBBACBS (n=6)	PNASL (n=3)	RBISPM (n=1)	Total overlap
Area overlap (km^2)	1.34	4.39	4.70	10.43
% overlap	58.48	5.00	56.95	10.60

The differences in the full selection frequency maps from the science-based (A1) and stakeholder-based (A2) approaches are shown in the "Difference map" in Figures 4.4a-d. In these maps, the Disagreement Index distinguishes between areas of high priority for the science-based approach (A1) only (i.e. negative large numbers in blue), areas of high priority for the stakeholder-based approach (A2) only (positive large numbers in red), and areas of agreement between the two approaches (small numbers in neutral light yellow in the middle) beyond the 10% selection frequency for both approaches (i.e. excluding areas that would be in high agreement due to the fact that neither approach selected them frequently).

I identify major areas of agreement and disagreement between the two approaches in six geographically distinct locations within the MIR. On the western side of the MIR, fishers heavily prioritized 12 km^2 of rocky reef area along the eastern coast of Isla Ángel de la Guarda, representing 17.20% of all rocky reef habitat in the MIR (Table 4.6). However, this only coincided with the science-based approach in six rocky reef sites around the island and six more surrounding Isla Dátil on the southeastern side. In Isla Ángel de la Guarda, the two approaches heavily differed at the top tip of the island where six planning units for rocky reef habitat, one for seagrass, three for rhodoliths, and two for spawning aggregations, were largely prioritized by the science-approach but not by the stakeholders (Figure 4.4a). The differences in rocky reef habitat priorization occurred in five other locations around the island where five other spawning sites were generally avoided by the stakeholders. Other areas of disagreement on the western coast of the MIR occur near Bahía de los Ángeles, where the science-based approach selects planning units heavily populated by rocky reef habitat, four rhodolith sites, three spawning aggregations, and two planning units with seagrass beds.

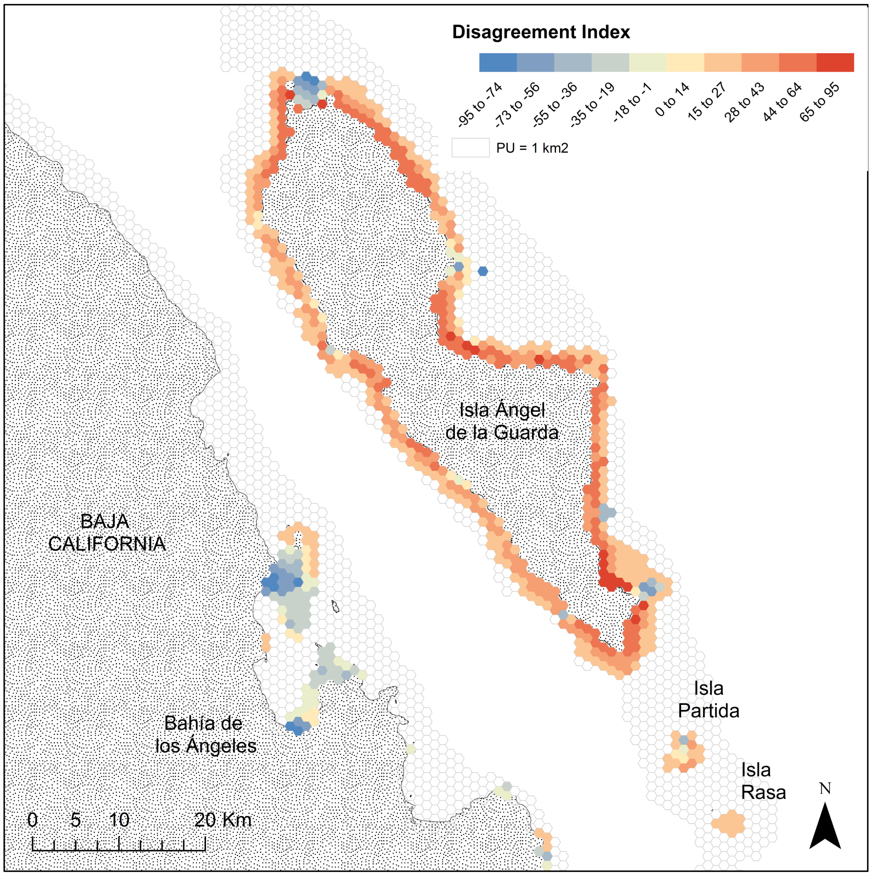

Figure 4.4a. Difference map of the central west coast of the MIR near Isla Ángel de la Guarda. Negative large numbers (blue) = high priority for A1, positive large numbers (red) = high priority for A2, and small numbers (neutral colors) = areas of agreement between A1 and A2 (beyond the 10% selection frequency for both).

On the southwestern and northwestern coasts of the MIR in Baja California, areas of disagreement also occurred where the science-based approach heavily selected rocky reef sites that were virtually avoided by fishers (Figure 4.4b). Although stakeholders heavily selected some rocky reef areas surrounding the islands of the National Park Archipelago San Lorenzo, they avoided three spawning aggregations.

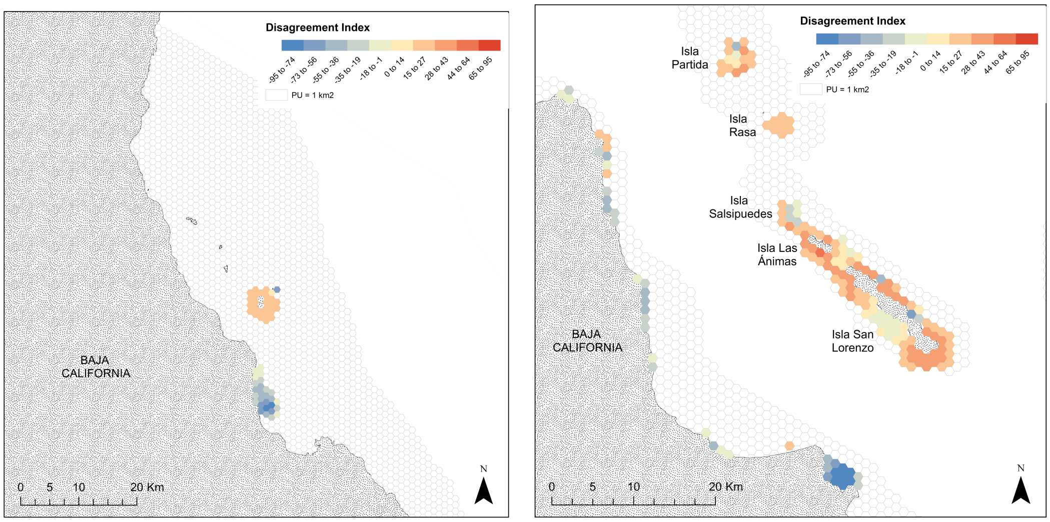

Figure 4.4b. Difference map of the northern (left) and southern (right) west coast of the MIR. Negative large numbers (blue) = high priority for A1, positive large numbers (red) = high priority for A2, and small numbers (neutral colors) = areas of agreement between A1 and A2 (beyond the 10% selection frequency for both).

Along the northeastern coast of the MIR in Sonora, rocky reef habitat and three spawning aggregations (north and south of Puerto Libertad) were also frequently selected by the science-approach and avoided by the stakeholders in three locations (Figure 4.4c, left). Planning units within and surrounding the Biosphere Reserve Isla San Pedro Mártir were frequently selected by the science-based approach in six spawning aggregation areas that stakeholders avoided, including four that lay outside of the NTA (Figure 4.4c, right).

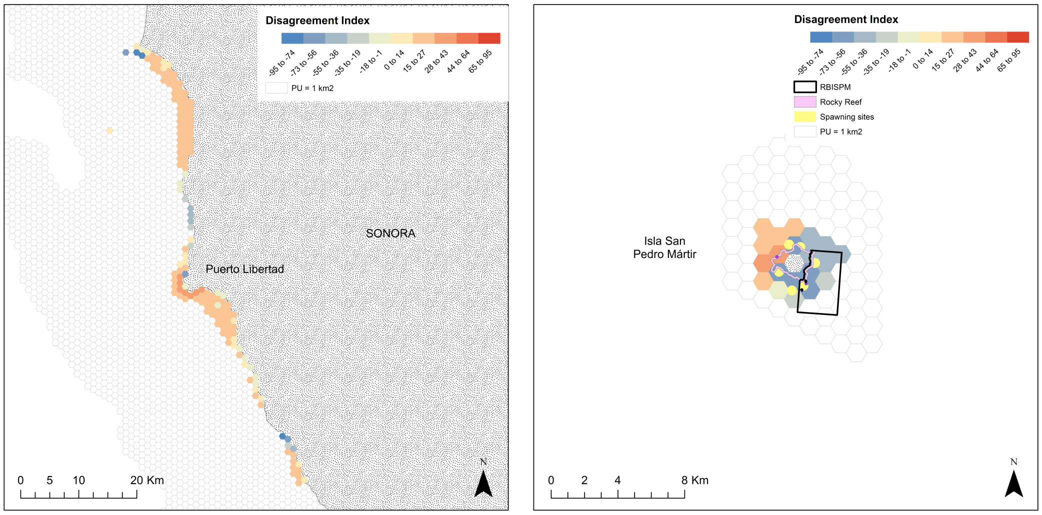

Figure 4.4c. Difference map of the northern (left) and southern (right) east coast of the MIR. Negative large numbers (blue) = high priority for A1, positive large numbers (red) = high priority for A2, and small numbers (neutral colors) = areas of agreement between A1 and A2 (beyond the 10% selection frequency for both).

On the central east coast of the MIR in Sonora, mangrove areas were also frequently selected in the stakeholder-based maps, with 7.2 km^2 of mangrove area within Estero Santa Cruz on the Sonoran mainland (representing 28.8% mangrove area in the MIR) but not so frequently selected in the science-based approach (with only three planning units of agreement between the two approaches) (Figure 4.4d). The same occurs with wetland habitat areas where only nine planning units were prioritized by the science-based approach but not by the stakeholder-based approach, which frequently had a much larger selection of planning units harboring wetland habitat.

Seagrass beds were frequently selected by the stakeholders more than in the science-based approach, especially within the Infiernillo Channel between Isla Tiburón and the Sonoran mainland. Once more, spawning aggregations were frequently avoided by stakeholders, with three sites in the southern tip of Isla Tiburón and two south of Isla Dátil being generally selected in the science-based approach but not by stakeholders. The same occurred on the northwest (3 spawning sites), and northeastern (2 spawning sites) sides of Isla Tiburón. Finally, most stakeholders frequently selected the rocky reef coast around Isla San Esteban, but missed four spawning aggregation sites that the science-based approach frequently selected. The similarities between the approaches can also be observed in the full selection frequency maps (Figure 4.5a-b).

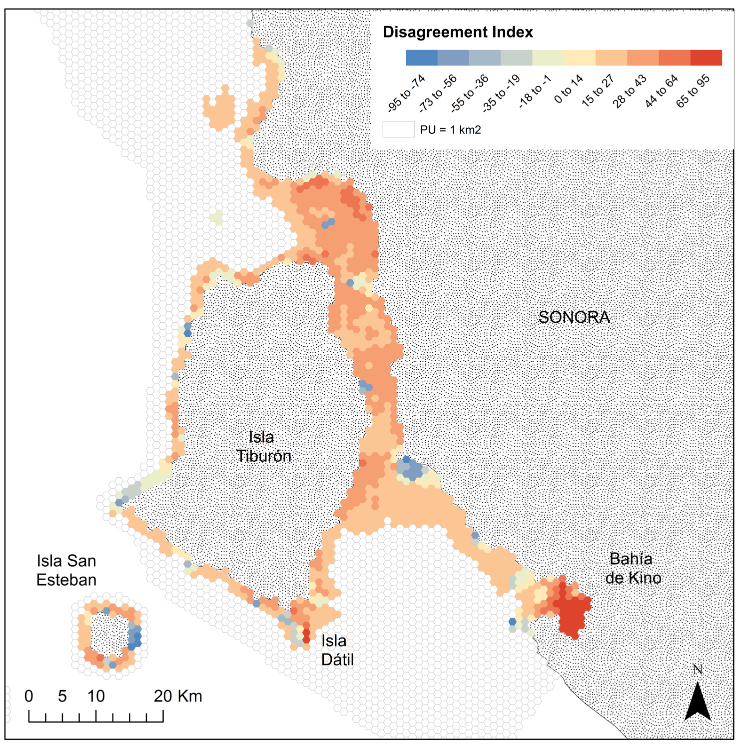

Figure 4.4d. Difference map of the central east coast of the MIR. Negative large numbers (blue) = high priority for A1, positive large numbers (red) = high priority for A2, and small numbers (neutral colors) = areas of agreement between A1 and A2 (beyond the 10% selection frequency for both).

For comparison of a final ‘best’ solution, I compared the ‘best’ Marxan outputs from the science-based approaches (A1 and A3) with the configuration of all 194 planning units that were selected by at least half of the fisher sample population in the stakeholder-based (A2) network. The stakeholder-based, science-based, and science-stakeholder agreement approach include 1.74, 2.57 and 2.63% of the planning area, respectively (Table 4.5).

Table 4.5. Area coverage of ‘best’ solutions for all three approaches.

Best Marxan Solution	# NTAs	Area (km^2)		
		Total	Max	Mean ± SD
A1. Science-based	70	285	25	4.10 ± 5.10
A2. Stakeholder-based	14	194	47	13.71 ± 15.56
A3. Science-stakeholder agreement	97	292	22	3.01 ± 3.76

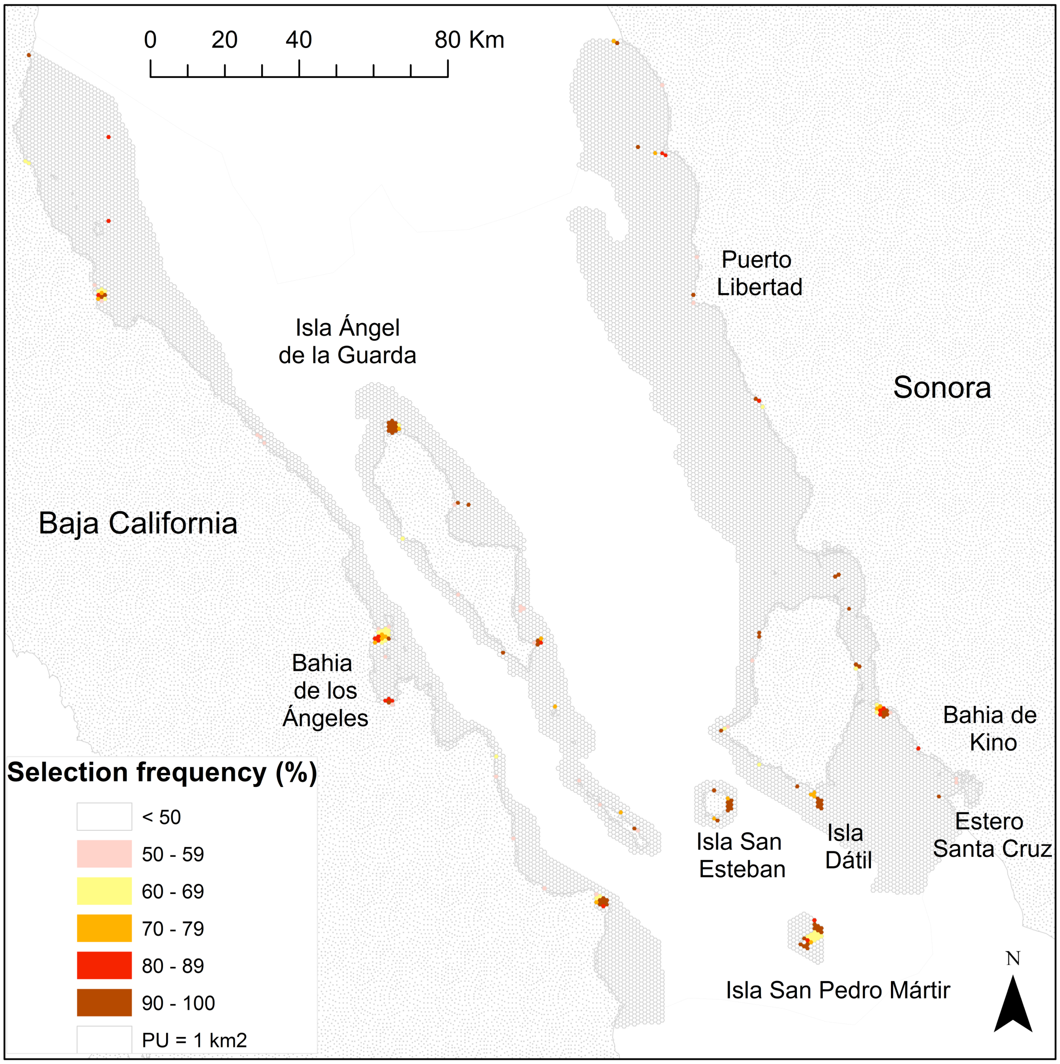

Figure 4.5a. Selection frequency of planning units for the A1 = Science-based approach.

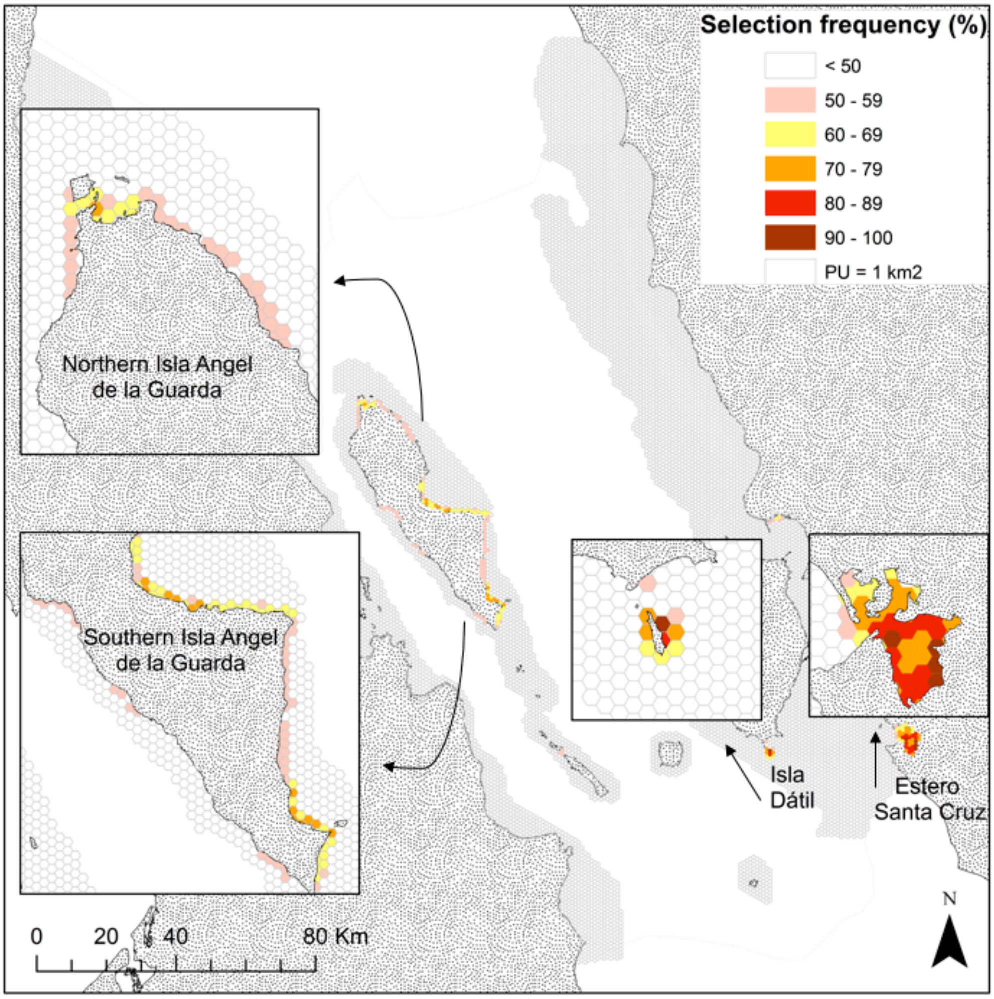

Figure 4.5b. Selection frequency of planning units for the A2 = Stakeholder-based approach.

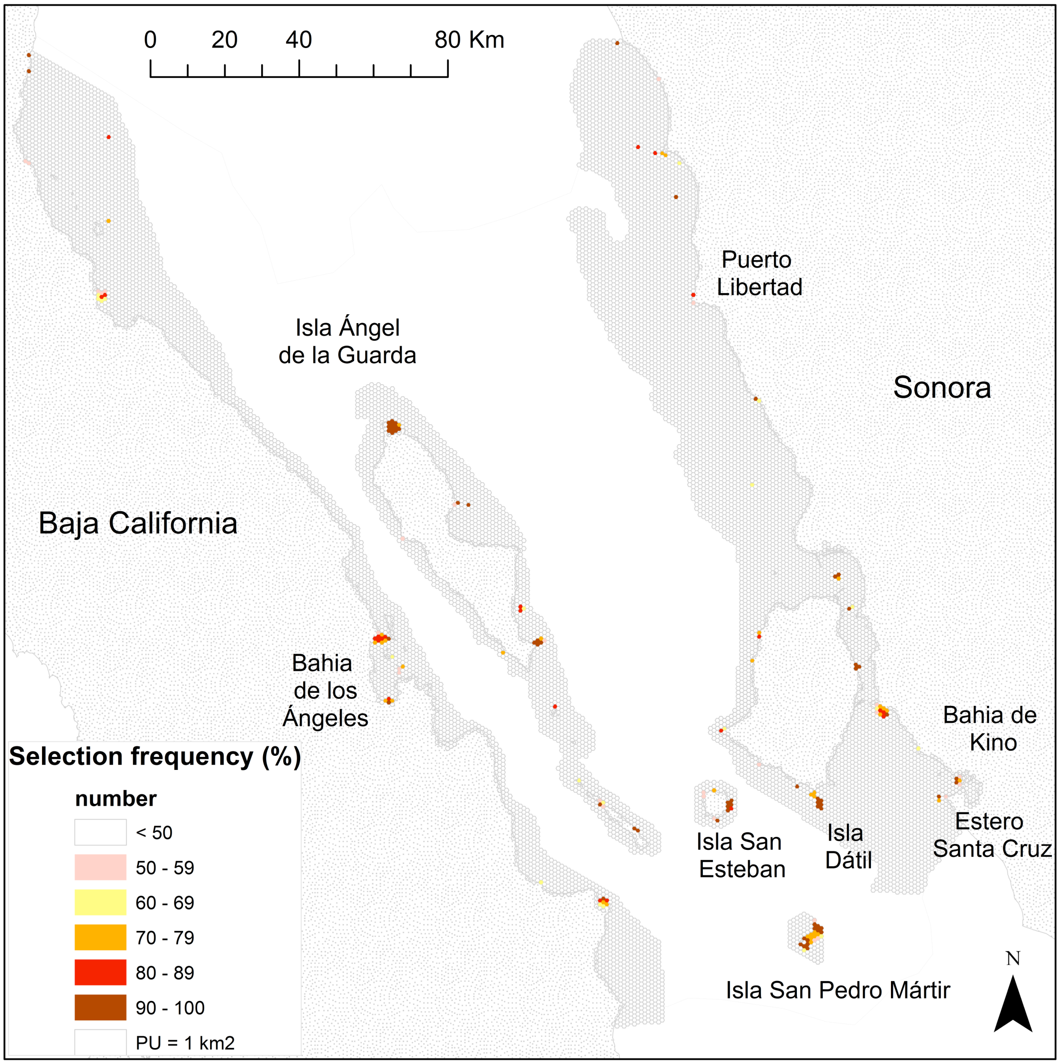

Figure 4.5c. Selection frequency of planning units for the A3 = Science-stakeholder agreement approach.

Table 4.6. Percent habitat included in 'best' solutions for all three approaches: A1 = Science-based; A2 = Stakeholder-based; A3 = Science-stakeholder agreement. ✓ = conservation objectives met.

	%		
Conservation feature	A1 (all ✓)	A2	A3 (all ✓)
Mangrove	20.8	28.8 ✓	20.2
Rocky reef	22.6	17.2 ✓	23.3
Sargassum forest	24.8	1.0	25.3
Seagrass beds	12.4	6.8 ✓	12.5
Wetland	20.1	6.2	20.0
Rhodolith sites	54.8	13.5	66.7
Spawning sites	69.1	10.3	72.8

The stakeholder-based approach (A2, Figure 4.5b) yielded a network configuration that included fourteen of the thirty-two individual conservation features in a total of 33.1 km^2 of habitat area. However, objectives were only met for mangrove, rocky reef, and seagrass bed habitat features, representing only 12.5% of all individual conservation features (Figure 4.6). The overall habitat coverage of these four features even surpassed the overall habitat conservation objectives for A2 (Table 4.6, Figure 4.7), with mangrove being represented by 19.6 % more than the desired objective, rocky reef 9.5 % more, and seagrass beds being represented by 1.4 % more. The average representation of the conservation features within the A2 network was 10.1% (± 3.5% SE). Three of the ten spawning aggregation sites were included in the A2 network design, representing only 66.3% less of what was desired as spawning area to be protected. Rhodolith sites and *Sargassum* forest habitat were also among the least represented within A2 (only two out of four features of each habitat were included) compared to the desired conservation objectives: *Sargassum* forest was represented 8.8% less than what was desired within the planning region, and this was 15.7% for rhodolith sites.

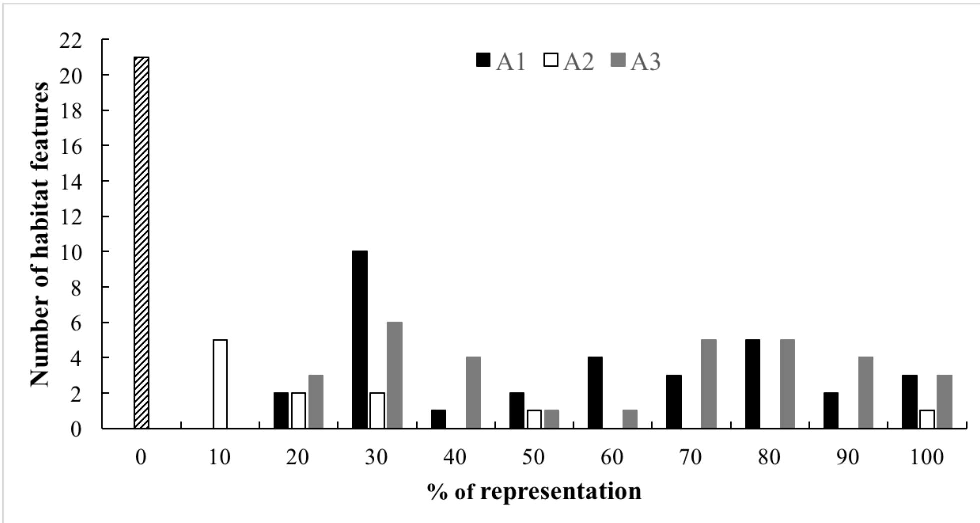

Figure 4.6. Proportion of habitat conservation features represented in the three different approaches using the best solution output (e.g. 10 features within the science-based approach (A1) have between 30% and 40% of their spatial coverage included in the best design). A1 = Science-based; A2 = Stakeholder-based; A3 = Science-stakeholder agreement. Hatched bar represents the number of features that were not represented in the stakeholder-based approach.

The seventeen planning units that were selected as among the A2 network configuration as most irreplaceable included a few mangrove, wetland, and seagrass bed areas in the Estero Santa Cruz near Bahía de Kino (and another seagrass bed on the southern tip of Isla Ángel de la Guarda), a couple of *Sargassum* forest sites in two islands north of Ángel de la Guarda, rhodolith sites north of Isla Ángel de la Guarda and near Isla

Dátil, and mainly shallow rocky reef sites around Isla San Dátil, Isla San Lorenzo-Las Ánimas, and along the northern and southern tips of Isla Ángel de la Guarda.

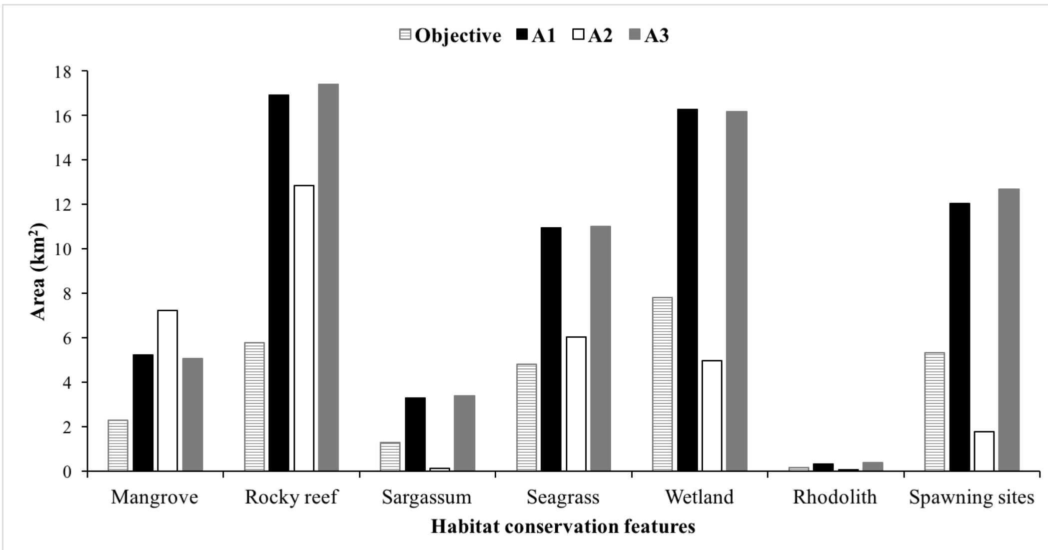

Figure 4.7. Total habitat and spawning site area represented in the three different approaches using the best solution output. A1 = Science-based; A2 = Stakeholder-based; A3 = Science-stakeholder agreement. Hatched bar represents the area to be represented within the network as part of each habitat conservation objective.

Constraining the science-based approach with the stakeholder preferences for irreplaceable planning units (A3) yields a network configuration that is very similar to A1 in terms of satisfying all the conservation objectives and protecting all habitat and spawning site features similarly with a slight increase of habitat protection by 1.08 km^2 (Figure 4.7). The average representation of the conservation features within the A3 network was 54.9% (± 5% SE), only slightly higher than that for A1 (51% ± 4.7% SE). Twenty-three individual habitat features were represented above 30 % in the A3 network compared to twenty in A1 (Figure 4.6). The science-stakeholder agreement approach also yielded a network configuration with the largest number of individual NTAs out of all three approaches, which although makes the network less compact, it is only 2.5 % larger than the science-based approach (Table 4.6). As expected, the opportunity cost of the stakeholder-based network configuration was lower than all the other approaches. However, constraining the science-based approach with the stakeholder-based preferences yielded a network configuration that was only 3.3% higher in opportunity cost than the A1 network (Figure 4.8).

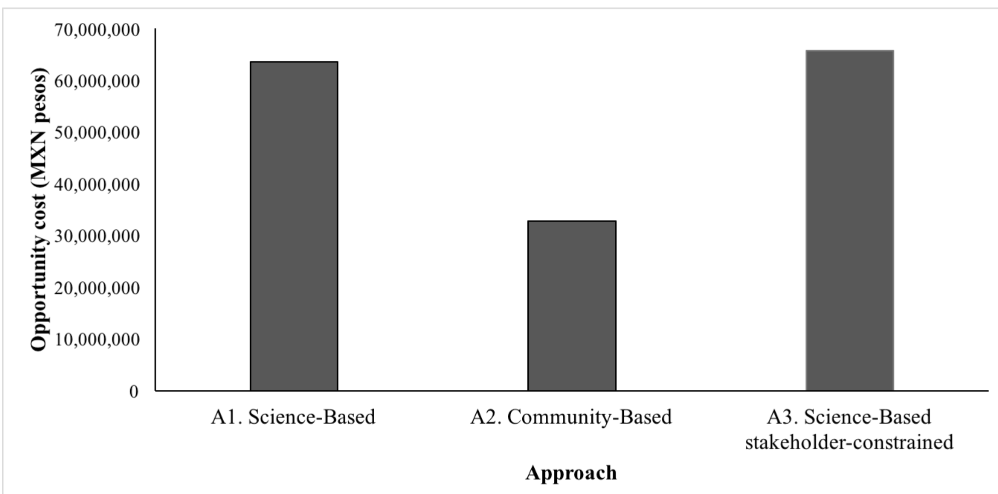

Figure 4.8. Sum of opportunity cost for all three approaches. A1 = Science-based; A2 = Stakeholder-based; A3 = Science-stakeholder agreement.

4.4 Discussion

Integrating scientific guiding principles about NTA design with ecological and socioeconomic criteria, local knowledge, and input from stakeholders has been demonstrated to be critical for achieving more effective NTA networks (Fernandes et al. 2005, Green et al. 2009, Gleason et al. 2010). However, large-scale planning of NTA networks requires a careful consideration of who and how stakeholders will be equally represented through a transparent and efficiently facilitated process that follows clear guidelines for participation, collaboration, communication, and problem solving (Gleason et al. 2010). Undertaking such detailed and early involvement of representatives from various communities within a large planning region while incorporating massive amounts of biological and socioeconomic sensitive data is not always feasible given practical, technical, or financial constraints.

Methods to integrate science-based and stakeholder-based approaches within SCP are now proposed as means to reach consensus between stakeholders and conservation practitioners and improve stakeholder acceptance and support for the suggested NTA networks (Ban et al. 2009b, Ruiz-Frau et al. 2015). The work presented here demonstrates the integration process of stakeholder-selected areas can be achieved with a large fisher sample (n=85) from three different fishing communities within a large planning region (~11,100 km^2 of coastal and marine areas) at a high resolution (1 km^2 planning units), and while using a novel cost layer representing opportunity cost of fishing (Adams et al. 2011, Álvarez-Romero et al. 2013). My results further support approaches that consider a systematic planning effort integrating the best available data in conjunction with stakeholder preferences for NTA placement without sacrificing conservation objectives and with minimal increases to cost. However, given the amount of disagreement between stakeholder and science-based approaches, I also show there is a strong need to carefully appraise stakeholder preferences for NTA placement with science-based approaches prior to carrying out a joint priorization effort that incorporates said preferences.

The stakeholder-based approach on its own resulted in a network that incorporated almost half of the individual conservation features being targeted by the science-based approach, was approximately a third smaller in total size, but decreased half the opportunity cost to fishers. Given the overall goal of the planning process, it is no surprise that fishers heavily selected areas of rocky reef habitat. The difference maps are represent an easy way to identify areas of major disagreement between the stakeholder-based and science-based approach, and it allows more scrutiny for determining whether stakeholders have particular underlying reasons for selecting areas that are either genuinely beneficial for a network of NTAs, or that are not useful to them for fishing (e.g. seagrass beds, mangrove, and wetland habitat near the coast or within the estuary) or are too far and pose big risks for traveling to fish there. High priority areas for stakeholders that are not high priority in the science-based approach (i.e. towards the red end of the spectrum on the Disagreement Index) could represent sites where fishers are not likely to go fishing. High priority areas in the science-based approach but not for stakeholders (i.e. towards the blue end of the spectrum on the Disagreement Index) could represent areas where fishers are either unaware of the relative importance of those sites for a NTA network or they chose not to select them for fear of losing important fishing areas for them (e.g. multiple spawning aggregations). Therefore, the difference maps help check the stakeholder data in terms of their usefulness for the NTA network. The Disagreement Index also helps identify the agreement threshold at which stakeholder-preferred areas are included into the science-based numerical optimization approaches (A3) to avoid selection of planning units that do not contribute to achieving conservation objectives at low cost.

On the other hand, it was also possible to identify areas already within a MPA and under controlled exploitation regimes such as the eastern coast of Isla Ángel de la Guarda as well as both northern and southern tips of the island, were heavily selected by most fishers as areas that are important for conservation and fisheries management, and could be under stricter levels of protection such as NTAs. Mangrove, seagrass bed, and wetland habitats in the southern part of the Sonoran coast were also highly prioritized by fishers, which tells us that fishers value areas well known for being nursery habitats for a myriad of species targeted in the MIR. Most of these areas, as well as Isla San Estéban, are also under further anthropogenic pressures (e.g. high levels of tourism, pollution, etc.) given their proximity to major touristic population centers such as Kino Nuevo in Bahía de Kino. The stakeholder-based approach, however, fell short at protecting some of the spawning aggregation sites which are of utmost importance for fish stock recovery.

The identification of a planning-unit lock-in proportion demonstrates a pragmatic and replicable way to integrate stakeholder-selected relevant areas (i.e. that are also relevant contributors to the network in terms of achieving conservation objectives) through science-based approaches and thus guarantee the ecological integrity of the NTA network. Constraining Marxan's optimization process resulted in a NTA network configuration that takes into consideration areas that have been accepted by fisher representatives as preferable and/or necessary, still achieved all conservation objectives, did not increase by much in terms of overall area, and suffered only a mild increase in terms of opportunity cost. This approach can be useful to conservation practitioners and fisheries managers seeking to identify potential NTAs that are both likely to be accepted by fisher community and achieve the desired outcomes without sacrificing efficiency. Furthermore, although existing NTAs were established with different conservation objectives, they can be evaluated for further additions and/or modifications that can incorporate some of the recommendations for NTAs put forth in the present study to increase protection of commercial species.

Several caveats should be considered in interpreting my results. First, stakeholder-based approaches will always be as good as the data collected for them. I make the important assumptions that fishers have complete knowledge about the presence and location of important conservation features (including habitats, species distribution, and spawning site locations), and that they provide us with accurate information on whether the sites they are selecting truly contribute to the functioning of the NTA network as opposed to being convenient sites that will not hamper fishing activities. I attempted to control for the latter by spreading the participatory mapping process into three exercises to achieve the most accurate answer possible. In similar studies, post-interview stakeholder meetings are often held to evaluate stakeholder-based approaches and achieve consensus among the interviewed fishers with respect to selected sites. However, my study shows there is value in assessing individual fisher preferences and how they are likely to affect or bias a combined science-stakeholder agreement approach.

Second, not incorporating distance to ports in the opportunity cost layer could bias the Marxan-based approaches (A1 and A3) by frequently selecting planning units that may have low opportunity cost to fishers but in reality are too distant for fishers to risk safety and additional resources (e.g. gas money) to travel and harvest there (Smith et al. 2010). By this logic, Marxan may be constricting itself from selecting planning units of high opportunity cost in terms of foregone revenue but that fishers would be willing to go given the high risk factors of traveling far distances. This phenomenon could explain some of the lack of overlap between the A2 and A1 approaches. Finally, my study only assessed the effect of incorporating of stakeholder preferences on habitat feature selection. Future research should consider consequences of the science- stakeholder agreement approach on the representation of fish and invertebrate species.

The planning exercise for the development of a full-scale network of NTAs presented here and in Álvarez-Romero et al. (*in review*) has been one of the most comprehensive ones in the history of the MIR in the GOC in terms of scope, data compilation, expert advice, and stakeholder input throughout its design. The incorporation of small-scale fisher preferences into the proposal for a NTA network in the region contributes to their efforts for increasing buy-in through the identification of: 1) acceptance level to the establishment of a NTA network by all stakeholders (i.e. fishers, government agencies, non-governmental organizations); 2) strategies to increase buy-in and expedite implementation; 3) potential tools to strengthen fisher capacity to participate in decision-making (Suárez-Castillo et al. 2017).

Key benefits of fisher involvement during the process of NTA design and establishment include gaining a deeper understanding of the needs and concerns of people directly affected by NTA establishment while generating trust and credibility among resource users (Pierce et al. 2005), and identifying issues of concern early on to avoid conflict and subsequent delays later in the process (Gleason et al. 2010). As Ban et al. (2009b) and Ruiz-Frau et al. (2015), I believe that integration of participatory design strategies with systematic science-based planning methods can improve, and even expedite, stakeholder buy-in and reduce resistance to NTA implementation as fishers feel empowered throughout the process and thus more likely to abide by the regulations implemented (Ban et al. 2009b, Gleason et al. 2010). My results emphasize the importance of incorporating fisher preferences as a way of engaging with the community early on during a large scale and complicated planning process.

While the use of numerical optimization tools such as Marxan with SCP approaches continues to increase, these tools are generally recommended to support, and not replace, stakeholder-driven NTA design processes (Klein et al. 2008). The importance of fisher perceptions of the pros and cons, both in the short- and long-term, of NTAs becomes important and will greatly influence their level of opposition towards their establishment. Incorporating local fishers' input in the design and implementation processes of NTA regulations is essential to long-term stewardship of NTAs (Lundquist and Granek 2005). The method and results presented in this study provides a salient example of ways that cutting-edge science can be combined with local expertise by integrating both science-based and stakeholder-based approaches to NTA selection in a participative, collaborative, and exploratory process to assess alternatives for NTA networks and ease implementation.

4.5 References

Adams, V. M., M. Mills, S. D. Jupiter, and R. L. Pressey. 2011. Improving social acceptability of marine protected area networks: A method for estimating opportunity costs to multiple gear types in both fished and currently unfished areas. Biological Conservation **144**:350-361.

Ainsworth, C. H., I. C. Kaplan, P. S. Levin, R. Cudney-Bueno, E. A. Fulton, M. Mangel, P. Turk-Boyer, J. Torre, A. Pares-Sierra, and H. Morzaria-Luna. 2011. Atlantis model development for the Northern Gulf of California. Seattle, WA.

Alvarez-Borrego, S. 1983. Gulf of California. Pages pp. 427-449 *in* B. H. Ketchum, editor. Estuaries and Enclosed Seas. Elsevier, Amsterdam, The Netherlands.

Alvarez-Borrego, S. 2007. Oceanografía. Pages 45-65 *in* G. D. Danemann and E. Ezcurra, editors. Bahía de los Ángeles: Recursos Naturales y Comunidad, Línea Base 2007. Pronatura Noroeste A.C., Secretaría de Medio Ambiente y Recursos Naturales, Instituto Nacional de Ecología, San Diego Natural History Museum.

Álvarez-Romero, J. G., A. Munguia-Vega, M. Beger, A. N. Suárez-Castillo, G. G. Gurney, V. M. Adams, R. L. Pressey, L. R. Gerber, M. M. Mancha-Cisneros, A. Castillo-Lopez, M. Kolb, H. N. Morzaria-Luna, H. Reyes-Bonilla, E. Graham, J. VanDerWal, and J. Torre-Cosío. *in review*. Designing marine reserve networks considering ecological connectivity and climate change: a practical application in the Midriff Islands, Gulf of California. Global Change Biology.

Álvarez-Romero, J. G., R. L. Pressey, N. C. Ban, J. Torre-Cosio, and O. Aburto-Oropeza. 2013. Marine conservation planning in practice: lessons learned from the Gulf of California. Aquatic Conservation: Marine and freshwater ecosystems **23**:483-505.

Anadon, J. D., C. D'Agrosa, A. Gondor, and L. R. Gerber. 2011. Quantifying the spatial ecology of wide-ranging marine species in the Gulf of California: implications for marine conservation planning. PLoS ONE **6**:e28400.

Ball, I., H. Possingham, and D. J. Watts. 2009. Marxan and relatives: software for spatial conservation prioritization. Pages 185-195 *in* A. Moilanen, K. Wilson, and H. Possingham, editors. Spatial Conservation Prioritization Quantitative Methods and Computational Tools. Oxford University Press, Oxford, UK.

Ban, N. C., G. J. A. Hansen, M. Jones, and A. C. J. Vincent. 2009a. Systematic marine conservation planning in data-poor regions: Socioeconomic data is essential. Marine Policy **33**:794-800.

Ban, N. C., C. R. Picard, and A. C. J. Vincent. 2009b. Comparing and integrating community-based and science-based approaches to prioritizing marine areas for protection. Conservation Biology **23**:899 - 910.

Brusca, R., L. T. Findley, P. Hastings, M. E. Hendrickx, J. Torre Cosio, and A. M. van der Heiden. 2005. Macrofaunal biodiversity in the Gulf of California. Pages 179 - 203 *in* J. L. E. Cartron, G. Ceballos, and R. S. Felger, editors. Biodiversity, Ecosystems, and Conservation in Northern Mexico. Oxford University Press, New Yotk.

Carvajal, M. A., A. Robles, and E. Ezcurra. 2010. Ecological conservation in the Gulf of California. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Christie, P. 2004. Marine protected areas as biological successes and social failures in Southeast Asia. American Fisheries Society Symposium **42**:155-164.

Christie, P., B.J. McCay, M.L. Miller, C. Lowe, A.T. White, R. Stoffle, D.L. Fluharty, L.T. McManus, R. Chuenpagdee, C. Pomeroy, D.O. Suman, B.G. Blount, D. Huppert, R.L.V. Eisma, E. Oracion, K. Lowry, and R.B. Pollnac. 2003. Toward developing a complete understanding: a social science research agenda for marine protected areas. Fisheries **28**:22-26.

Cinner, J. E. 2007. Designing marine reserves to reflect local socioeconomic conditions: lessons from long-enduring customary management systems. Coral Reefs **26**:1035-1045.

Cinti, A., J. N. Duberstein, E. Torreblanca, and M. Moreno-Baez. 2014. Overfishign drivers and opportuities for recovery in small-scale fisheries of the Midriff Islands Region, Gulf of California, Mexico: the roles of land and sea institutions in fisheries sustainability. Ecology and Society **19**:15.

Cinti, A., W. Shaw, R. Cudney-Bueno, and M. Rojo. 2010. The unintended consequences of formal fisheries policies: Social disparities and resource overuse in a major fishing community in the Gulf of California, Mexico. Marine Policy **34**:328-339.

Cisneros-Mata, M. A. 2010. The importance of fisheries in the Gulf of California and ecosystem-based sustainable co-management for conservation. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

CONABIO, CONANP, TNC, and PRONATURA. 2007. Analisis de vacios y omisiones en conservacion de la biodiversidad marina en Mexico: Oceanos, costas e islas. Mexico, D.F.

CONAPESCA. 2011. Anuario estadistico de acuacultura y pesca. Comisión Natural de Acuacultura y Pesca, México, DF, México.

Elith, J., S. J. Phillips, T. Hastie, M. Dudík, Y. E. Chee, and C. J. Yates. 2011. A statistical explanation of MaxEnt for ecologists. Diversity and Distributions **17**:43-57.

Erisman, B., I. Mascarenas, G. Paredes, Y. S. de Mitcheson, O. Aburto-Oropeza, and P. Hastings. 2010. Seasonal, annual, and long-term trends in commercial fisheries for aggregating reef fishes in the Gulf of California, Mexico. Fisheries Research **106**:279 - 288.

Fernandes, L., J. Day, A. Lewis, S. Slegers, B. Kerrigan, D. Breen, D. Cameron, B. Jago, J. Hall, D. Lowe, J. Innes, J. Tanzer, V. Chadwick, L. Thompson, K. Gorman, M. Simmons, B. Barnett, K. Sampson, G. De'Ath, B. Mapstone, H. Marsh, H. Possingham, I. Ball, T. Ward, K. Dobbs, J. Aumend, D. Slater, and K. Stapleton. 2005. Establishing representative no-take areas in the Great Barrier Reef: Large-scale implementation of theory on marine protected areas. Conservation Biology **19**:1733-1744.

Fraschetti, A., J. Claudet, and K. Grorud-Colvert. 2011. Management - Transitioning from single-sector management to ecosystem-based management: What can marine protected areas offer?*in* J. Claudet, editor. Marine Protected Areas, A Multidisciplinary Approach. Cambridge University Press, New York, USA.

Gill, D., M. B. Mascia, G. N. Ahmadia, L. Glew, S. E. Lester, M. Barnes, I. Craigie, E. S. Darling, C. M. Free, J. Geldmann, S. Holst, O. P. Jensen, A. T. White, X. Basurto, L. Coad, R. D. Gates, G. Guannel, P. J. Mumby, H. Thomas, S. Whitmee, S. Woodley, and H. E. Fox. 2017. Capacity shortfalls hinder the performance of marine protected areas globally. Nature **543**:665 - 669.

Gleason, M., S. McCreary, M. Miller-Henson, J. Ugoretz, E. Fox, M. Merrifield, W. McClintock, P. Serpa, and K. Hoffman. 2010. Science-based and stakeholder-driven marine protected area network planning: A successful case study from north central California. Ocean and Coastal Management **53**:52–68.

Green, A., S. E. Smith, G. Lipsett-Moore, C. Groves, N. Peterson, S. Sheppard, P. Lokani, R. Hamilton, J. Almany, J. Aitsi, and L. Bualia. 2009. Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. Oryx **43**:488–498.

Klein, C. J., C. Steinback, A. J. Scholz, and H. P. Possingham. 2008. Effectiveness of marine reserve networks in representing biodiversity and minimizing impact to fishermen: a comparison of two approaches used in California. Conservation Letters **1**:44 ' 51.

Lluch-Cota, S. E., E. A. Aragon-Noriega, F. Arreguin-Sanchez, D. Aurioles-Gamboa, J. J. Bautista-Romero, R. C. Brusca, R. Cervantes-Duarte, R. Cortes-Altamirano, P. Del-Monte-Luna, A. Esquivel-Herrera, G. Fernandez, M. E. Hendrickx, S. Hernandez-Vazquez, H. Herrera-Cervantes, M. Kahru, M. Lavin, D. Lluch-Belda, D. B. Lluch-Cota, J. Lopez-Martinez, S. G. Marinone, M. O. Nevarez-Martinez, S. Ortega-Garcia, E. Palacios-Castro, A. Pares-Sierra, G. Ponce-Diaz, M. Ramirez-Rodriguez, C. A. Salinas-Zavala, R. A. Schwartzlose, and A. P. Sierra-Beltran. 2007. The Gulf of California: Review of ecosystem status and sustainability challenges. Progress In Oceanography **73**:1-26.

Lundquist, C. J., and E. F. Granek. 2005. Strategies for successful marine conservation: integrating socioeconomic, political, and scientific factors. Conservation Biology **19**:1771-1778.

Mancha-Cisneros, M. M., A. N. Suarez-Castillo, J. Torre, J. M. Anderies, and L. R. Gerber. *in review*. The role of stakeholder perceptions and institutions for marine reserve efficacy in the Midriff Islands Region, Gulf of California, Mexico. Ocean & Coastal Management.

McClanahan, T. R. 1999. Is there a future for coral reef parks in poor tropical countries? Coral Reefs **18**:321-325.

Micheli, F., B. S. Halpern, L. W. Botsford, and R. R. Warner. 2004. Trajectories and correlates of community change in no-take marine reserves. Ecological Applications **14**:1709-1723.

Moreno-Báez, M., R. Cudney-Bueno, B. J. Orr, W. W. Shaw, T. Pfister, J. Torre-Cosio, R. Loaiza, and M. Rojo. 2012. Integrating the spatial and temporal dimensions of fishing activities for management in the Northern Gulf of California, Mexico. Ocean and Coastal Management **55**:111-127.

Munguia-Vega, A., J. Torre, P. Turk-Boyer, S. G. Marinone, M. Lavin, T. Pfister, W. W. Shaw, G. D. Danemann, P. Raimondi, A. Castillo-Lopez, A. Cinti, J. N. Duberstein, M. Moreno-Baez, M. Rojo, G. Soria, L. Sanchez-Velasco, H. Morzaria-Luna, L. Bourillon, K. Rowell, and R. Cudney-Bueno. 2015. PANGAS: An Interdisciplinary Ecosystem-Based Research Framework for Small-Scale Fisheries in the Northern Gulf of California. Journal of the Southwest **57**:337 - 390.

Pierce, S. M., R. M. Cowling, A. T. Knight, A. T. Lombard, M. Rouget, and T. Wolf. 2005. Systematic conservation planning products for land-use planning: Interpretation for implementation. Biological Conservation **125**:441–458.

Pressey, R. L., and M. C. Bottril. 2009. Approaches to landscape- and seascape-scale conservation planning: convergence, contrasts and challenges. Oryx **43**:464–475.

Richardson, E. A., M. J. Kaiser, G. Edward-Jones, and H. P. Possingham. 2006. Sensitivity of Marine-Reserve Design to the Spatial Resolution of Socioeconomic Data. Conservation Biology **20**:1191 - 1202.

Ruiz-Frau, A., H. Possingham, G. Edward-Jones, C. J. Klein, D. Segan, and M. J. Kaiser. 2015. A multidisciplinary approach in the design of marine protected areas: Integration of science and stakeholder based methods. Ocean & Coastal Management **103**:86-93.

Smith, M. D., J. Lynham, J. N. Sanchirico, and J. A. Wilson. 2010. Political economy of marine reserves: Understanding the role of opportunity costs. Proceedings of the National Academy of Sciences **107**:18300-18305.

Stewart, R. R., and H. P. Possingham. 2005. Efficiency, costs and trade-offs in marine reserve system design. Environmental Modeling and Assessment **10**:203 - 213.

Suárez-Castillo, A. N. 2014. Bosques de Sargassum en el Golfo de California: estrategias para su conservación y manejo Universidad Autónoma de Baja California Sur, La Paz, Baja California Sur, México.

Suárez-Castillo, A. N., J. Torre, M. J. Espinosa-Romero, M. M. Mancha-Cisneros, and J. G. Alvarez-Romero. 2017. Ruta de Sociabilización para integrar al sector productivo en una propuesta de red de zonas de recuperación pesquera en la región de las Grandes Islas, Golfo de California. Ciencia Pesquera ***in press***.

White, A. T., A. Salamanca, and C. A. Courtney. 2002. Experience with marine protected area planning and management in the Philippines. Coastal Management **30**:1 – 26.

REFERENCES

Aburto-Oropeza, O., E. Ezcurra, J. Moxley, A. Sánchez-Rodríguez, I. Mascareñas-Osorio, C. Sánchez-Ortiz, B. Erisman, and T. Ricketts. 2015. A framework to assess the health of rocky reefs linking geomorphology, community assemblage, and fish biomass. Ecological Indicators **52**:353 - 361.

Adams, V. M., M. Mills, S. D. Jupiter, and R. L. Pressey. 2011. Improving social acceptability of marine protected area networks: A method for estimating opportunity costs to multiple gear types in both fished and currently unfished areas. Biological Conservation **144**:350-361.

Agardy, T., P. Bridgewater, M. P. Crosby, J. Day, P. K. Dayton, R. Kenchington, D. Laffoley, P. McConney, P. A. Murray, J. E. Parks, and L. Peau. 2003. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation: Marine and freshwater ecosystems **13**:353-367.

Agrawal, A. 2003. Sustainable governance of common-pool resources: context, methods, and politics. Annual Review of Anthropology **32**:243-262.

Ainsworth, C. H., I. C. Kaplan, P. S. Levin, R. Cudney-Bueno, E. A. Fulton, M. Mangel, P. Turk-Boyer, J. Torre, A. Pares-Sierra, and H. Morzaria-Luna. 2011. Atlantis model development for the Northern Gulf of California. Seattle, WA.

Alvarez-Borrego, S. 1983. Gulf of California. Pages pp. 427-449 *in* B. H. Ketchum, editor. Estuaries and Enclosed Seas. Elsevier, Amsterdam, The Netherlands.

Alvarez-Borrego, S. 2007. Oceanografía. Pages 45-65 *in* G. D. Danemann and E. Ezcurra, editors. Bahía de los Ángeles: Recursos Naturales y Comunidad, Línea Base 2007. Pronatura Noroeste A.C., Secretaría de Medio Ambiente y Recursos Naturales, Instituto Nacional de Ecología, San Diego Natural History Museum.

Álvarez-Romero, J. G., A. Munguia-Vega, M. Beger, A. N. Suárez-Castillo, G. G. Gurney, V. M. Adams, R. L. Pressey, L. R. Gerber, M. M. Mancha-Cisneros, A. Castillo-Lopez, M. Kolb, H. N. Morzaria-Luna, H. Reyes-Bonilla, E. Graham, J. VanDerWal, and J. Torre-Cosío. *in review*. Designing marine reserve networks considering ecological connectivity and climate change: a practical application in the Midriff Islands, Gulf of California. Global Change Biology.

Álvarez-Romero, J. G., R. L. Pressey, N. C. Ban, J. Torre-Cosio, and O. Aburto-Oropeza. 2013. Marine conservation planning in practice: lessons learned from the Gulf of California. Aquatic Conservation: Marine and freshwater ecosystems **23**:483-505.

Anadon, J. D., C. D'Agrosa, A. Gondor, and L. R. Gerber. 2011. Quantifying the spatial ecology of wide-ranging marine species in the Gulf of California: implications for marine conservation planning. PLoS ONE **6**:e28400.

Anderies, J. M. 2015. Understanding the Dynamics of Sustainable Social-Ecological Systems: Human Behavior, Institutions, and Regulatory Feedback Networks Bulletin of Mathematical Biology **77**:259-280.

Anderies, J. M., and M. A. Janssen. 2013. Robustness of Social-Ecological-Systems: Implications for public policy Policy Studies Journal **41**:513-536.

Anderies, J. M., M. A. Janssen, and E. Ostrom. 2004. A framework to analyse the robustness of Social-Ecological-Systems from an institutional perspective. Ecology and Society **9**:18.

Anderies, J. M., M. A. Janssen, and E. Schlager. 2016. Institutions and the performance of coupled infrastructure systems. International Journal of the Commons **10**:495 - 516.

Arias, A., J. E. Cinner, R. E. Jones, and R. L. Pressey. 2015. Levels and drivers of fishers' compliance with marine protected areas. Ecology and Society **20**:19.

Arias, A., and S. Sutton. 2013. Understanding Recreational Fishers' Compliance with No-take Zones in the Great Barrier Reef Marine Park. Ecology and Society **18**:18.

Aswani, S., and P. Weiant. 2004. Scientific evaluation in women's participatory management: monitoring marine invertebrate refugia in the Solomon Islands. Human Organization **63**:301-319.

Ayala-Bocos, A., H. Reyes-Bonilla, L. E. Calderón-Aguilera, M. D. Herrero-Perezrul, and P. C. González-Espinosa. 2016. Forecasting changes in sea surface temperature in the Gulf of California, and theirs effects on abundance and distribution of reef species. Revista Ciencias Marinas y Costeras **8**:29 - 40.

Ball, I., H. Possingham, and D. J. Watts. 2009. Marxan and relatives: software for spatial conservation prioritization. Pages 185-195 *in* A. Moilanen, K. Wilson, and H. Possingham, editors. Spatial Conservation Prioritization Quantitative Methods and Computational Tools. Oxford University Press, Oxford, UK.

Ban, N. C., G. J. A. Hansen, M. Jones, and A. C. J. Vincent. 2009a. Systematic marine conservation planning in data-poor regions: Socioeconomic data is essential. Marine Policy **33**:794-800.

Ban, N. C., C. R. Picard, and A. C. J. Vincent. 2009b. Comparing and integrating community-based and science-based approaches to prioritizing marine areas for protection. Conservation Biology **23**:899 - 910.

Basurto, X., L. Bourillon, and J. Torre. 2000. The role of a Non-Governmental Organization (NGO) in an emerging co-management regime: the Mexican Seri Indians' case study. Proceedings of the 8th Biennial conference of the International Association for Study of Common Property (IASCP):26.

Basurto, X., A. Cinti, L. Bourillon, M. Rojo, J. Torre-Cosio, and A. Hudson Weaver. 2012. The emergence of access controls in small-scale fishing commons: A comparative analysis of individual licenses and common property-rights in two mexican communities. Human Ecology **40**:597-609.

Basurto, X., and E. Coleman. 2010. Institutional and ecological interplay for successful self-governance of community-based fisheries. Ecological Economics **69**:1094-1103.

Becker, C. D., and E. Ostrom. 1995. Human ecology and resource sustainability: the importance of institutional diversity. Annual Review of Ecology and Systematics **26**:113-133.

Bennett, N. J., and P. Dearden. 2014a. From measuring outcomes to providing inputs: governance, management, and local development for more effective marine protected areas. Marine Policy **50**:96 - 110.

Bennett, N. J., and P. Dearden. 2014b. Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. Marine Policy **44**:107 - 116.

Bergseth, B., J. Cinner, and G. Russ. 2015. Measuring and monitoring compliance in no-take marine reserves. Fish and Fisheries **16**:240-258.

Berkes, F., and C. Folke. 1998. Linking Social and Ecological Systems for Resilience and Sustainability. Pages 1–25 *in* F. Berkes and C. Folke, editors. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge Univerisity Press, Cambridge, UK.

Bernstein, B., S. Iudicello, and C. Stringer. 2004. Lessons learned from recent marine protected area designations in the United States. National Fisheries Conservation Center, Ojai, CA.

Bourillon, L., and J. Torre. 2012. Areas marinas protegidas del Golfo de California para mitigar los efectos de la pesca de arrastre en la biodiversidad: Limitaciones y propuesta de nuevo enfoque. Pages 399 - 411 *in* J. Lopez-Martinez and E.

Morales-bojorquez, editors. Efectos de la pesca de arrastre en el Golfo de California. Centro de Investifaciones Biologicas del Noroeste, S.C. y Fundacion Produce Sonora, Mexico.

Brusca, R., L. T. Findley, P. Hastings, M. E. Hendrickx, J. Torre Cosio, and A. M. van der Heiden. 2005. Macrofaunal biodiversity in the Gulf of California. Pages 179 - 203 *in* J. L. E. Cartron, G. Ceballos, and R. S. Felger, editors. Biodiversity, Ecosystems, and Conservation in Northern Mexico. Oxford University Press, New Yotk.

Brusca, R., and M. E. Hendrickx. 2010. Invertebrate biodiversity and conservation in the Gulf of California. Pages 72 - 95 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Carvajal, M. A., A. Robles, and E. Ezcurra. 2010. Ecological conservation in the Gulf of California. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

CEMDA, and COBI. 2010. Implementacion de Reservas Marinas en Mexico.

Charles, A., and L. Wilson. 2009. Human dimensions of marine protected areas. ICES Journal of Marine Science **66**:6-15.

Christie, P. 2004. Marine protected areas as biological successes and social failures in Southeast Asia. American Fisheries Society Symposium **42**:155-164.

Christie, P., B.J. McCay, M.L. Miller, C. Lowe, A.T. White, R. Stoffle, D.L. Fluharty, L.T. McManus, R. Chuenpagdee, C. Pomeroy, D.O. Suman, B.G. Blount, D. Huppert, R.L.V. Eisma, E. Oracion, K. Lowry, and R.B. Pollnac. 2003. Toward developing a complete understanding: a social science research agenda for marine protected areas. Fisheries **28**:22-26.

Cinner, J., T. M. Daw, C. Huchery, P. Thoya, A. Wamukota, M. Cedras, and C. Abunge. 2014. Winners and losers in marine conservation: Fisher's experiences of displacement and perceptions of spillover from marine protected areas in Seychelles and Kenya. Society & Natural Resources **27**:994-1005.

Cinner, J. E. 2005. Socioeconomic factors influencing customary marine tenure in the Indo-Pacific. Ecology and Society **10**:36.

Cinner, J. E. 2007. Designing marine reserves to reflect local socioeconomic conditions: lessons from long-enduring customary management systems. Coral Reefs **26**:1035-1045.

Cinner, J. E., M. J. Marnane, and T. R. McClanahan. 2005. Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. Conservation Biology **19**:1714-1723.

Cinti, A., J. N. Duberstein, E. Torreblanca, and M. Moreno-Baez. 2014. Overfishign drivers and opportuities for recovery in small-scale fisheries of the Midriff Islands Region, Gulf of California, Mexico: the roles of land and sea institutions in fisheries sustainability. Ecology and Society **19**:15.

Cinti, A., W. Shaw, R. Cudney-Bueno, and M. Rojo. 2010a. The unintended consequences of formal fisheries policies: Social disparities and resource overuse in a major fishing community in the Gulf of California, Mexico. Marine Policy **34**:328-339.

Cinti, A., W. W. Shaw, and J. Torre. 2010b. Insights from the users to imrpove fisheries performance: Fisher's knowledge and attitudes on fisheries policie sin Bahia de Kino, Gulf of California, Mexico. Marine Policy **34**:1322-1334.

CIRVA-5. 2014. Report of the Fifth meeting of the 'Comité Internacional para la recuperación de la vaquita'. Ensenada, B.C., Mexico.

Cisneros-Mata, M. A. 2010. The importance of fisheries in the Gulf of California and ecosystem-based sustainable co-management for conservation. Pages 119 - 134 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Cisneros-Mata, M. A., M. J. Espinosa-Romero, E. A. Ramírez-Félix, V. I. González-Gallardo, C. Gómez-Rojo, and J. Torre. 2014. Proceso de elaboración y resultados preliminares del Plan de Manejo para las Pesquerías de Jaiba en Sinaloa y Sonora. Informe de Investigación. . DGIPN.

Cisneros-Montemayor, A. M., M. A. Cisneros-Mata, S. Harper, and D. Pauly. 2013. Extent and implications of IUU catch in Mexico's marine fisheries. Marine Policy **39**:283-288.

Cisneros-Montemayor, A. M., and A. C. J. Vincent. 2016. Science, society, and flagship species: social and political history as keys to conservation outcomes in the Gulf of California. Ecology and Society **21**:9.

Colding, J., and C. Folke. 2001. Social taboos: "Invisible" systems of local resource management and biological conservation. Ecological Applications **11**:584-600.

CONABIO, CONANP, TNC, and PRONATURA. 2007. Analisis de vacios y omisiones en conservacion de la biodiversidad marina en Mexico: Oceanos, costas e islas. Mexico, D.F.

CONANP-SEMARNAT. 1995. Programa de Conservación y Manejo Reserva de la Biósfera Alto Golfo de California y Delta Río Colorado. Mexico, D.F.

CONANP-SEMARNAT. 2007. Programa de Conservación y Manejo Reserva de la Biósfera Isla San Pedro Mártir. Comisión Nacional de Áreas Naturales Protegidas y Secretaría del Medio Ambiente y de los Recursos Naturales, México, D.F. .

CONAPESCA. 2011. Anuario estadistico de acuacultura y pesca. Comisión Natural de Acuacultura y Pesca, México, DF, México.

Crawford, B. R., A. Siahainenia, C. Rotinsulu, and A. Sukmara. 2004. Compliance and enforcement of community-based coastal resource management regulations in North Sulawesi, Indonesia. Coastal Management **32**:39-50.

Cudney-Bueno, R., L. Bourillo, A. Saenz-Arroyo, J. Torre-Cosio, P. Turk-Boyer, and W. W. Shaw. 2009. Governance and effects of marine reserves in the Gulf of California, Mexico. Ocean & Coastal Management **52**:207-218.

Díaz-Uribe, J. G., F. Arreguín-Sánchez, D. Lercari-Bernier, V. H. Cruz-Escalona, M. J. Zetina-Rejón, P. del-Monte-Luna, and S. Martínez-Aguilar. 2012. An integrated ecosystem trophic model for the North and Central Gulf of California: An alternative view for endemic species conservation. Ecological Modelling **230**:73–91.

DOF. 1978. Decreto por el que se establece una zona de reserva y refugio de aves migratorias y de la fauna silvestre, en las islas que se relacionan, situadas en el Golfo de California. Diaro Oficial de la Federación.

DOF. 1988. Ley General del Equilibrio Ecológico y la Protección al Ambiente, Última reforma publicada DOF 13-05-2016. Diario Oficial de la Federación.

DOF. 2000a. Acuerdo que tiene por objeto dotar con una categoría acorde con la legislación vigente a las superficies que fueron objeto de diversas declaratorias de áreas naturales protegidas emitidas por el Ejecutivo Federal. Diaro Oficial de la Federación.

DOF. 2000b. Ley General de Vida Silvestre, ;ultimas reformas publicadas DOF 13-05-2016. Diario Oficial de la Federación.

DOF. 2005. ACUERDO mediante el cual se establece el área de refugio para la protección de la vaquita (Phocoena sinus).

DOF. 2007. Ley General de Pesca y Acuacultura Sustentables, Nueva Ley publicada en el DOF el 24 de julio de 2007 y última reforma publicada DOF 04-06-2015. Diario Oficial de la Federación.

DOF. 2014. NOM-049-SAG/PESC-2014, Que determina el procedimiento para establecer zonas de refugio para los recursos pesqueros en aguas de jurisdicción federal de los Estados Unidos Mexicanos. .

DOF. 2015. ACUERDO por el que se suspende temporalmente la pesca comercial mediante el uso de redes de enmalle, cimbras y/o palangres operadas con embarcaciones menores, en el Norte del Golfo de California. Diaro Oficial de la Federación.

Elith, J., S. J. Phillips, T. Hastie, M. Dudík, Y. E. Chee, and C. J. Yates. 2011. A statistical explanation of MaxEnt for ecologists. Diversity and Distributions **17**:43-57.

Erisman, B., I. Mascarenas, G. Paredes, Y. S. de Mitcheson, O. Aburto-Oropeza, and P. Hastings. 2010. Seasonal, annual, and long-term trends in commercial fisheries for aggregating reef fishes in the Gulf of California, Mexico. Fisheries Research **106**:279 - 288.

Espinosa-Romero, M. J., A. A. Rodriguez, A. Hudson Weaver, C. Villanueva-Aznar, and J. Torre. 2014. The changing role of NGOs in Mexican small-scale fisheries: From environmental conservation to multi-scale governance. Marine Policy **50**:290 - 299.

Espinosa-Romero, M. J., and J. Torre. 2012. Implementando el enfoque ecosistémico al manejo pesquero. Caso de Estudio: Puerto Libertad, Sonora. .

Fernandes, L., J. Day, B. Kerrigan, D. Breen, G. De'Ath, B. Mapstone, R. Coles, T. Done, H. Marsh, I. Poiner, T. Ward, D. Williams, and R. Kenchington. 2009. A process to design a network of marine no-take areas: Lessons from the Great Barrier Reef. Ocean and Coastal Management **52**:439-447.

Fernandes, L., J. Day, A. Lewis, S. Slegers, B. Kerrigan, D. Breen, D. Cameron, B. Jago, J. Hall, D. Lowe, J. Innes, J. Tanzer, V. Chadwick, L. Thompson, K. Gorman, M. Simmons, B. Barnett, K. Sampson, G. De'Ath, B. Mapstone, H. Marsh, H. Possingham, I. Ball, T. Ward, K. Dobbs, J. Aumend, D. Slater, and K. Stapleton. 2005. Establishing representative no-take areas in the Great Barrier Reef: Large-scale implementation of theory on marine protected areas. Conservation Biology **19**:1733-1744.

Fernberg, P., J. E. Caselle, J. Claudet, M. Clemence, S. D. Gaines, J. A. Garcia-Charton, E. J. Goncalvez, K. Grorud-Colvert, P. Guidetti, S. R. Jenkins, P. J. S. Jones, S. E.

Lester, R. McAllen, E. Moland, P. S., and T. K. Sorensen. 2012. The science of European marine reserves: Status, efficacy, and future needs. Marine Policy **36**:1012-1021.

Ferse, S. C. A., M. Mañez Costa, K. Schwerdtner Mañez, D. S. Adhuri, and M. Glaser. 2010. Allies, not aliens: increasing the role of local communities in marine protected area implementation. Environmental Conservation **37**:23-34.

Fraschetti, A., J. Claudet, and K. Grorud-Colvert. 2011. Management - Transitioning from single-sector management to ecosystem-based management: What can marine protected areas offer?*in* J. Claudet, editor. Marine Protected Areas, A Multidisciplinary Approach. Cambridge University Press, New York, USA.

Fujitani, M. L., E. P. Fenichel, J. Torre, and L. R. Gerber. 2012. Implementation of a marine reserve has a rapid but short-lived effect on recreational angler use. Ecological Applications **22**:597-605.

García-Hernández, J., M. J. Espinosa-Romero, M. A. Cisneros-Mata, G. Leyva-García, D. Aguilera-Márquez, and J. Torre Cosio. 2015. Concentración de mercurio y plaguicidas organoclorados (poc) en tejido comestible de jaiba café *Callinectes bellicosus* de las costas de Sonora y Sinaloa, México. Ciencia Pesquera **23**:65 - 79.

Gill, D., M. B. Mascia, G. N. Ahmadia, L. Glew, S. E. Lester, M. Barnes, I. Craigie, E. S. Darling, C. M. Free, J. Geldmann, S. Holst, O. P. Jensen, A. T. White, X. Basurto, L. Coad, R. D. Gates, G. Guannel, P. J. Mumby, H. Thomas, S. Whitmee, S. Woodley, and H. E. Fox. 2017. Capacity shortfalls hinder the performance of marine protected areas globally. Nature **543**:665 - 669.

Gleason, M., S. McCreary, M. Miller-Henson, J. Ugoretz, E. Fox, M. Merrifield, W. McClintock, P. Serpa, and K. Hoffman. 2010. Science-based and stakeholder-driven marine protected area network planning: A successful case study from north central California. Ocean and Coastal Management **53**:52–68.

Green, A., S. E. Smith, G. Lipsett-Moore, C. Groves, N. Peterson, S. Sheppard, P. Lokani, R. Hamilton, J. Almany, J. Aitsi, and L. Bualia. 2009. Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. Oryx **43**:488–498.

Green, A. L., L. Fernandes, G. Almany, R. Abesamis, E. McLeod, P. M. Aliño, A. T. White, R. Salm, J. Tanzer, and R. L. Pressey. 2014. Designing Marine Reserves for Fisheries Management, Biodiversity Conservation, and Climate Change Adaptation. Coastal Management

42:143-159.

Gurney, G., J. E. Cinner, J. Sartin, R. L. Pressey, N. C. Ban, N. Marshall, and D. Prabuning. 2006. Participation in devolved commons management: Multiscale socioeconomic factors related to individuals' participation in community-based management of marine protected areas in Indonesia Environmental Science and Policy **61**:212-220.

Gurney, G., R. L. Pressey, J. E. Cinner, R. Pollnac, and S. Campbell. 2015. Integrating Conservation and Development: evaluating a community-based marine protected area project for equity of socioeconomic impacts. Philosophical Transactions of the Royal Society B:20140277.

Hastings, P., L. T. Findley, and A. M. van der Heiden. 2010. Fishes of the Gulf of California. Pages 96 - 118 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Herman, H. 2004. El papel de las organizaciones de la sociedad civil en el manejo costero en México. Pages 115–132 *in* Rivera-Arriaga, Villalobos-Zapata, Azuz-Adeath, and Rosado-May, editors. El manejo costero en México.

Hilborn, R., K. Stokes, J. J. Maguire, T. Smith, L. W. Botsford, M. Mangel, J. Orensanz, A. Parma, J. Rice, J. Bell, K. L. Cochrane, S. Garcia, S. J. Hall, G. P. Kirkwood, K. Sainsbury, G. Stefansson, and C. Walters. 2004. When can marine reserves improve fisheries management? Ocean & Coastal Management **47**:197–205.

IMCO. 2013. La pesca ilegal e irregular en Mexico: Una barrera a la competitividad. . México, D.F.

INEGI. 2010. Censo de Poblacion y Vivienda.

Jentoft, S., T. C. van Son, and M. Bjørkan. 2007. Marine protected areas: a governance system analysis. Human Ecology **35**:611-622.

Jones, P. J. S. 2014. Governing Marine Protected Areas: Resilience through diversity. Routledge, Oxon, UK.

Kareiva, P. 2006. Conservation Biology: Beyond Marine Protected Areas. Current Biology **16**:R533-R535.

Kiser, L. L., and E. Ostrom. 1982. The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches. Pages 179–222 *in* E. Ostrom, editor. Strategies of Political Inquiry. Sage, Beverly Hills, CA.

Klein, C. J., C. Steinback, A. J. Scholz, and H. P. Possingham. 2008. Effectiveness of marine reserve networks in representing biodiversity and minimizing impact to fishermen: a comparison of two approaches used in California. Conservation Letters **1**:44 ' 51.

Koch, V. 2015. Análisis Comparativo de Instrumentos para la Conservación y el Uso Sustentable de la Biodiversidad en el Golfo de California. Ciudad de México.

Leslie, H. M., X. Basurto, M. Nenadovic, L. Sievanen, K. C. Cavanaugh, J. J. Cota-Nieto, B. Erisman, E. Finkbeiner, G. Hinojosa-Arango, M. Moreno-Baez, S. Nagavarapu, S. M. W. Reddy, A. Sanchez-Rodriguez, K. Siegel, J. J. Ulibarria-Valenzuela, A. Hudson Weaver, and O. Aburto-Oropeza. 2015. Operationalizing the social-ecological systems framework to assess sustainability. Proceedings of the National Academy of Sciences **112**:5979 - 5984.

Lluch-Cota, S. E., E. A. Aragon-Noriega, F. Arreguin-Sanchez, D. Aurioles-Gamboa, J. J. Bautista-Romero, R. C. Brusca, R. Cervantes-Duarte, R. Cortes-Altamirano, P. Del-Monte-Luna, A. Esquivel-Herrera, G. Fernandez, M. E. Hendrickx, S. Hernandez-Vazquez, H. Herrera-Cervantes, M. Kahru, M. Lavin, D. Lluch-Belda, D. B. Lluch-Cota, J. Lopez-Martinez, S. G. Marinone, M. O. Nevarez-Martinez, S. Ortega-Garcia, E. Palacios-Castro, A. Pares-Sierra, G. Ponce-Diaz, M. Ramirez-Rodriguez, C. A. Salinas-Zavala, R. A. Schwartzlose, and A. P. Sierra-Beltran. 2007. The Gulf of California: Review of ecosystem status and sustainability challenges. Progress In Oceanography **73**:1-26.

Lundquist, C. J., and E. F. Granek. 2005. Strategies for successful marine conservation: integrating socioeconomic, political, and scientific factors. Conservation Biology **19**:1771-1778.

Mancha-Cisneros, M. M., and L. R. Gerber. 2015. Guiding principles for green economic development in the marine environment: Insights from small-scale fisheries and marine protected areas.*in* A. Gasparatos and K. J. Willis, editors. Biodiversity in the Green Economy. Routledge, London, U.K.

Mancha-Cisneros, M. M., A. N. Suarez-Castillo, J. Torre, J. M. Anderies, and L. R. Gerber. *in review*. The role of stakeholder perceptions and institutions for marine reserve efficacy in the Midriff Islands Region, Gulf of California, Mexico. Ocean & Coastal Management.

McCay, B. J., F. Micheli, G. Ponce-Díaz, G. Murray, G. Shester, S. Ramrez-Sanchez, and W. Weisman. 2014. Cooperatives, concessions, and co-management on the Pacific coast of Mexico. Marine Policy **44**:49 - 59.

McClanahan, T. R. 1999. Is there a future for coral reef parks in poor tropical countries? Coral Reefs **18**:321-325.

McClanahan, T. R., M. J. Marnane, J. E. Cinner, and W. E. Kiene. 2006. A comparison of marine protected areas and alternative approaches to coral-reef management. Current Biology **16**:1408-1413.

McGinnis, M. D. 2011. An introduction to IAD and the langauge of the Ostrom Workshop: A simple guide to a complex framework. Policy Studies Journal **39**:169 - 183.

Meza-Monge, A., M. J. Espinosa-Romero, and J. Torre-Cosio. 2015. Difundiendo los instrumentos legales para el aprovechamiento sustentable de la jaiba en Sonora, México. Ciencia Pesquera **23**:91 - 100.

Micheli, F., B. S. Halpern, L. W. Botsford, and R. R. Warner. 2004. Trajectories and correlates of community change in no-take marine reserves. Ecological Applications **14**:1709-1723.

Micheli, F., A. Saenz-Arroyo, A. Greenley, L. Vazquez, J. A. Espinoza Montes, M. Rossetto, and G. A. De Leo. 2012. Evidence that marine reserves enhance resilience to climatic impacts. PLoS ONE **7** e40832.

Moreno-Báez, M., R. Cudney-Bueno, B. J. Orr, W. W. Shaw, T. Pfister, J. Torre-Cosio, R. Loaiza, and M. Rojo. 2012. Integrating the spatial and temporal dimensions of fishing activities for management in the Northern Gulf of California, Mexico. Ocean and Coastal Management **55**:111-127.

Morzaria-Luna, H. 2016. Determinación de la extensión y situación actual de reservas marinas en la Región de las Grandes Islas (RGI) y Norte del Golfo de California para reducir los efectos del cambio climático en la producción pesquera y la función del ecosistema. Tucson, AZ.

Munguia-Vega, A., J. Torre, P. Turk-Boyer, S. G. Marinone, M. Lavin, T. Pfister, W. W. Shaw, G. D. Danemann, P. Raimondi, A. Castillo-Lopez, A. Cinti, J. N. Duberstein, M. Moreno-Baez, M. Rojo, G. Soria, L. Sanchez-Velasco, H. Morzaria-Luna, L. Bourillon, K. Rowell, and R. Cudney-Bueno. 2015. PANGAS: An Interdisciplinary Ecosystem-Based Research Framework for Small-Scale Fisheries in the Northern Gulf of California. Journal of the Southwest **57**:337 - 390.

Niño-Torres, C. A., J. Urbán-Ramírez, and O. Vidal. 2011. Mamíferos Marinos del Golfo de California: Guía ilustrada.

Ostrom, E. 1990. Governing the commons: The evolution of institutions for collective action. Cambridge University Press, Cambridge.

Ostrom, E. 2005. Understanding Institutional Diversity. Princeton University Press, Princeton, NJ.

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas.

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science **325**:419-422.

Ostrom, E. 2011. Background on the Institutional Analysis and Development Framework. Policy Studies Journal **39**:7-27.

Ostrom, E., R. Gardner, and J. Walker. 1994. Rules, Games, and Common-Pool Resources. University of Michigan Press, Ann Arbor, MI, USA.

Pierce, S. M., R. M. Cowling, A. T. Knight, A. T. Lombard, M. Rouget, and T. Wolf. 2005. Systematic conservation planning products for land-use planning: Interpretation for implementation. Biological Conservation **125**:441–458.

Pollnac, R., P. Christie, J. E. Cinner, T. Dalton, T. M. Daw, G. E. Forrester, N. A. J. Graham, and T. R. McClanahan. 2010. Marine reserves as linked social-ecological systems. Proceedings of the National Academy of Sciences **107**:18262-18265.

Poteete, A. R., M. A. Janssen, and E. Ostrom. 2010. Working together: Collective action, the commons, and multiple methods in practice. Princeton University Press Princeton, New Jersey.

Précoma de la Mora, M. 2015. Distribución potencial de peces de importancia comercial en el norte del Golfo de California, México: influencia del cambio climático sobre las principales áreas de pesca de la zona. , Ensenada, Baja California, México.

Pressey, R. L., and M. C. Bottril. 2009. Approaches to landscape- and seascape-scale conservation planning: convergence, contrasts and challenges. Oryx **43**:464–475.

Revollo-Fernández, D. A. 2012 Eficiencia técnica, social y económica de la pesquería de abulón bajo un esquema de gestión por medio de reservas marinas: el caso de Isla Natividad, Baja California. Universidad Nacional Autónoma de México, México, D.F. .

Richardson, E. A., M. J. Kaiser, G. Edward-Jones, and H. P. Possingham. 2006. Sensitivity of Marine-Reserve Design to the Spatial Resolution of Socioeconomic Data. Conservation Biology **20**:1191 - 1202.

Rife, A. N., B. Erisman, A. Sanchez, and O. Aburto-Oropeza. 2013. When good intentions are not enough...Insights on networks of "paper park" marine protected areas. Conservation Letters **6**:200-212.

Ruiz-Frau, A., H. Possingham, G. Edward-Jones, C. J. Klein, D. Segan, and M. J. Kaiser. 2015. A multidisciplinary approach in the design of marine protected areas: Integration of science and stakeholder based methods. Ocean & Coastal Management **103**:86-93.

Saarman, E., M. Gleason, J. Ugoretz, S. Airamé, M. Carr, E. Fox, A. Frimodig, T. Mason, and J. Vasques. 2013. The role of science in supporting marine protected area network planning and design in California. Ocean and Coastal Management **74**:45-56.

Sale, P. F., R. K. Cowen, B. S. Danilowicz, G. P. Jones, J. P. Kritzer, K. C. Lindeman, S. Planes, N. V. C. Polunin, G. R. Russ, Y. J. Sadovy, and R. S. Steneck. 2005. Critical science gaps impede use of no-take fishery reserves. TRENDS in Ecology and Evolution **20**:74-80.

Sanchirico, J. N., D. Holland, K. Quigley, and M. Fina. 2006. Catch-quota balancing in multispecies individual fishing quotas. Marine Policy **30**:767-785.

Sanchirico, J. N., and J. E. Wilen. 2001. A bioeconomic model of marine reserve creation. Journal of Environmental Economics and Management **42**:257-276.

Seminoff, J. A. 2010. Sea turtles of the Gulf of California. Pages 135 - 167 *in* R. Brusca, editor. The Gulf of California, biodiversity and conservation. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press, Tucson.

Smith, M. D., J. Lynham, J. N. Sanchirico, and J. A. Wilson. 2010. Political economy of marine reserves: Understanding the role of opportunity costs. Proceedings of the National Academy of Sciences **107**:18300-18305.

Smith, M. D., and J. E. Wilen. 2003. Economic impacts of marine reserves: the importance of spatial behavior. Journal of Environmental Economics and Management **46**:183 - 206.

Smith, M. D., and J. E. Wilen. 2004. Marine reserves with endogenous ports: empirical bioeconomics of the California sea urchin fishery. Marine Resource Economics **18**:85 - 112.

Soberanes Fernández, J. L. 1994. Historia Contemporánea de la Legislación Pesquera en México. Pages 1 - 26 *in* M. González Oropeza and M. A. Garita Alonso, editors.

El Régimen Jurídico de la Pesca en México. Instituto de Investigaciones Jurídicas, Mexico.

Spalding, M., I. Meliane, N. J. Bennett, P. Dearden, G. Pawan, P. G. Patil, and R. D. Brumbaugh. 2016. Building towards the marine conservation end-game: consolidating the role of MPAs in a future ocean. Aquatic Conservation: Marine and freshwater ecosystems **26**:185 - 199.

Stewart, R. R., and H. P. Possingham. 2005. Efficiency, costs and trade-offs in marine reserve system design. Environmental Modeling and Assessment **10**:203 - 213.

Suárez-Castillo, A. N. 2014. Bosques de Sargassum en el Golfo de California: estrategias para su conservación y manejo Universidad Autónoma de Baja California Sur, La Paz, Baja California Sur, México.

Suárez-Castillo, A. N., J. Torre, M. J. Espinosa-Romero, M. M. Mancha-Cisneros, and J. G. Alvarez-Romero. 2017. Ruta de Sociabilización para integrar al sector productivo en una propuesta de red de zonas de recuperación pesquera en la región de las Grandes Islas, Golfo de California. Ciencia Pesquera ***in press***.

Torre, J., E. Rolón, M. J. Espinosa-Romero, and S. Fulton. 2016. Zonas de recuperación marina como herramientas de conservación y pesca sustentable en México.*in* Biodiversidad, editor. Análisis y propuestas para la conservación de la biodiversidad en México.

Ulloa, R., J. Torre, L. Bourillon, A. Gonder, and N. Alcantar. 2007. Planeacion para la conservacion marina: Golfo de California y costa occidental de Baja California Sur. Comunidad y Biodiversidad, A.C., Guaymas, Mexico.

Weigel, J. Y., K. O. Mannle, N. J. Bennett, E. Carter, L. Westlund, V. Burgener, Z. Hoffman, A. S. Da Silva, E. A. Kane, J. Sanders, C. Piante, S. Wagiman, and A. Hellman. 2014. Marine protected areas and fishers: Bridging the divide. Aquatic Conservation: Marine and freshwater ecosystems **24**:199 - 215.

White, A., and C. A. Courtney, editors. 2004. Policy instruments for coral reef management and their effectiveness. 2nd edition. World Fish Center Conference Proceedings.

White, A. T., A. Salamanca, and C. A. Courtney. 2002. Experience with marine protected area planning and management in the Philippines. Coastal Management **30**:1 – 26.

Yin, R. K. 2014. Case study research: designs and methods. SAGE Publications, Thousand Oaks, CA.

Zepeda-Domínguez, J. A., M. J. Zetina-Rejón, A. Espinoza-Tenorio, G. Ponce-Díaz, D. Lluch-Belda, M. J. Espinosa-Romero, J. Torre-Cosio, and M. A. Cisneros-Mata. 2015. Mapeo topológico de los actores involucrados en el manejo de la pesquería de jaiba café *Callinectes bellicosus* en Sonora, México. Ciencia Pesquera **23**:81 - 90.

APPENDIX A

RESEARCH PROTOCOL FOR CHAPTER 2: ESSENTIAL SOCIO-ECOLOGIC FACTORS FOR THE IMPLEMENTATION AND SUCCESS OF A MARINE RESERVE IN THE GULF OF CALIFORNIA, MEXICO

A1. Introduction

I am a graduate student under the direction of Professor Leah Gerber in the College of Liberal Arts and Sciences at Arizona State University. I am conducting a research study to compare across case studies of marine reserves and analyze the ecologic, social, economic, and institutional factors that contribute to their implementation and success as fisheries recovery zones. This interview is intended to get to know the story about the origins and trajectories of marine reserves in the Gulf of California, Mexico, with respect to their decree, establishment, and current functioning.

A2. The Study

Conservation and fisheries management efforts to establish marine reserves often fail to include local communities in the design and implementation of the reserves and their management regulations. The purpose of the study is to unpack the social, economic, institutional, and ecological factors that are relevant to the interactions between the use of marine reserves as fisheries management tools and their efficacy in addressing their stated objectives at both a regional and local scale by evaluating case studies of marine reserves in the Gulf of California (GOC) that have strikingly different trajectories with respect to marine reserve design, establishment, and management. I will carry out a qualitative analysis on 10 case studies of GOC communities that have been involved or affected by the establishment of a marine reserve. More specifically, I will address the following questions: A) What are the key vulnerabilities of marine reserves in the Gulf of California and what is the role of the institutional structure that governs the operation of marine reserves in Mexico? B) To what extent do feedbacks within these systems affect the outcome of reserves that benefit humans and nature? The information for this analysis will come from an interview process with key informants and local experts (including representatives from non-profit organizations, government agencies, and scientific researchers well familiarized with the area) of the various communities in the GOC that have been associated with the establishment of marine reserves.

A3. Methods

I am inviting you to participate in an interview of 30 questions that will last a total of 1hr to 1hr & 30 minutes. I will read the questions to you and you can answer at your own pace while I type the answers. You have the right not to answer any question, and to stop participation at any time. I would also like to record the interview to make sure I capture all the necessary information. You can also choose to stop the recording at any point.

A4. Confidentiality and Anonymity

Your responses will be kept confidential, and your name will not be used as I am obligated to maintain the anonymity of all participants. In order to maintain anonymity, I will save the Word documents containing the interview responses and store them under unique code identifiers, which will be the only identifiers used to store, process, and analyze data. I am the only person who will have access to the electronic copies of the interviews in a password-protected electronic database on a secure ASU server (Gerber Lab server) until Summer of 2017. The data will only be analyzed and utilized for the purposes of scientific research.

A5. Participation and Information Sharing

Your participation in this study is voluntary, and you must be 18 years or older to participate. You have the right not to participate or to withdraw from the study at any time. The results of this study may be used in reports, presentations, or publications by myself. Your responses to the interview will only be used for scientific research purposes, and although there is no direct benefit to you, possible benefits of your participation include a better understanding of your point of view on the topic of marine reserves as management tools for fisheries and biodiversity in the Gulf of California, Mexico. A better understanding will help us make better recommendations for management strategies in the future, thus your participation is very valuable for the success of the fisheries in the region and the conservation of its biodiversity.

If you have any questions concerning the research study, please contact the research team at: (Mar.Mancha@asu.edu, Leah.Gerber@asu.edu). If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788. Please let me know if you wish to be part of the study.

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Leah Gerber Life Sciences, School of (SOLS)
480/727-3109, Leah.Gerber@asu.edu

Dear Leah Gerber: On 9/28/2016 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Interview to identify the essential socio-ecologic factors for the implementation and success of a marine reserve in the Gulf of California, Mexico
Investigator:	Leah Gerber
IRB ID:	STUDY00005008
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Gerber_Mancha_Governance_Recruit_ENG, Category: Recruitment Materials; • Gerber_Mancha_Governance_Recruit_SPA, Category: Recruitment Materials; • Gerber_Mancha_Governance_Interview_SPA, Category: Translations; • Gerber_Mancha_Governance_Protocol, Category: IRB Protocol; • Gerber_Mancha_Governance_Interview_ENG, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Translation Certificate, Category: Translations; • Gerber_Mancha_Governance_Consent_SPA, Category: Consent Form; • Gerber_Mancha_Governance_Consent_ENG, Category: Consent Form;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 9/28/2016.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

APPENDIX B

INTERVIEW TO IDENTIFY THE ESSENTIAL SOCIO-ECOLOGIC FACTORS FOR THE IMPLEMENTATION AND SUCCESS OF A MARINE RESERVE IN THE GULF OF CALIFORNIA, MEXICO

1) <STORYS> Let's talk about the origins of this marine reserve, particularly about the history of its design and implementation. When, by who, and why did the idea to establish a marine reserve arise?

2) <ACTORS> ¿Who were the main actors participating in the process of establishing this reserve?

3) <SUPPOR> Which groups of actors gave the most support for its establishment? Which actors gave the least support for its establishment?

4) <MGMPRG> When was the Management Plan published? If there were any delays in publishing it, why do you think that was? Has the plan been re-evaluated? If so, when?

5) <COMMUN> Which local communities do you think resulted most affected (either positively or negatively) by the establishment of the reserve?

6) <SECTOR> What are the main economic sectors in these communities?

7) <FISHER> What percentage of the population in these communities is exclusively engaged in fishing activities?

8) <OBJECTI> What are the main objectives of the marine reserve?

9) <OBJCHNG> Despite these objectives being described in the decree or management plan, do you think these have changed since the reserve was implemented? If so, how?

10) <OTHACT> Besides fishing, what other activities do you think need to be regulated or monitored in order to achieve the objectives of the marine reserve? Why?

11) <CONFLIC> What were the main conflicts that arose when the idea to establish the marine reserve was communicated to the community, particularly with the fishing sector (either artisanal or industrial)? Which of these conflicts do you think are still present?

12) <DRIVERS> At a large scale, what major local, national, and/or international forces you think are behind these activities in 3a <OTHACT>?

13) <POLITIC> Do you think there were any conventions or public policies at the federal, regional, or international level that may have influenced the implementation if this marine reserve? And if so, could you please describe what convention or public policy are you referring to?

14) <EFFFACT> Why? What factors do you think impede/facilitate the effectiveness of the marine reserve in achieving its stated objectives?

15) <EFFECOL> Would you consider this marine reserve to have been ecologically effective?

16) <EFFECON> Would you consider this marine reserve to have been socio-economically effective?

17) <LEADER> Would you say that the leadership qualities of certain key actors or members of the community has been an important factor for the implementation of this marine reserve? Why? What about for its performance?

18) <NGOCSO> Would you consider the participation of non-profit organizations during the design, implementation, and follow-up of the marine reserve has been an important factor for its official decree? What about for its performance? Are there any non-profit organizations in this particular area that are worth noting here?

19) <UNOFFI> Besides the no-fishing restrictions within the marine reserve, do you know of any unofficial rules or norms that are implemented in the area to prevent the nearby fisheries from becoming overexploited?

20) <MONCOMP> To your knowledge, are there people who act as monitors of rule compliance? If so, are there specific groups that do this?

21) <HHARINF> Is there any type of physical hard infrastructure (explain if needed)) that are lacking or needed to help achieve the reserve objectives?

22) <HSOFINF> Is there any type of soft infrastructure (explain if needed) that are lacking or needed to help achieve the reserve objectives?

23) <MONINFR> To your knowledge, are there people in charge of monitoring that these pieces of adequate infrastructure are present, functional, and effective towards helping achieve the marine reserve objectives?

24) <NATINF> Are there certain biophysical attributes in the area that have facilitated the zonification and/or monitoring of the marine reserve?

25) <CURRES> Would you consider the current state of the marine resources within the marine reserve to be in high abundance and/or good quality?

26) <PROCES> Are there certain biophysical/ecologic processes within or around the marine reserve that have contributed to its performance?

27) <STIGMA> To your knowledge, is there any sort of social sanctions (or stigma) among those who are found not complying with the reserve regulations or unofficial norms?

28) <LOCKNOW> Would say that the local knowledge of the communities has contributed to the appropriate design and subsequent performance of the marine reserve? How so?

29) <HUMINF> Are there any other capacities, abilities, or levels of experience that you think members of the communities have and that have contributed to the reserve's success?

30) <INFORM> To your knowledge, is there any information available for the direct resource uses with respect to the specifics of the marine reserve? If so, in what format?

APPENDIX C

ADDITIONAL FIGURES FOR CHAPTER 2

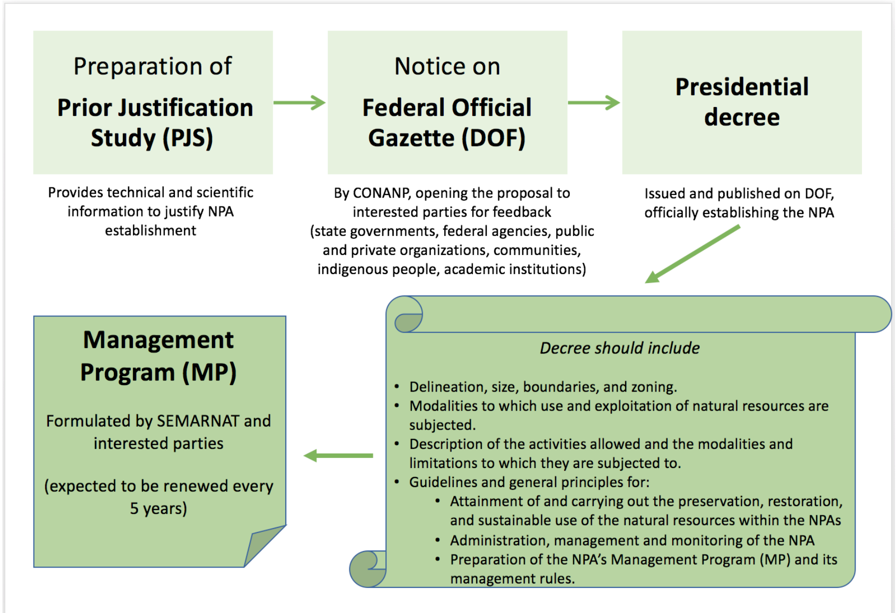

Figure 1C. Procedure establishing (and subsequently modifying) Natural Protected Areas under federal jurisdiction.

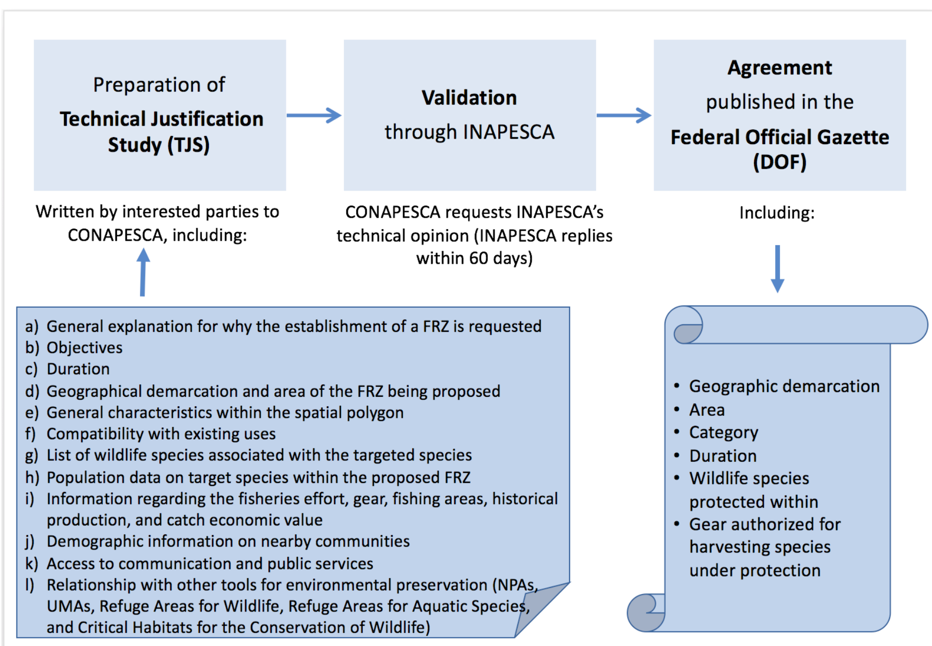

Figure 2C. Procedure for establishing Fishing Refuge Zones.

APPENDIX D

RESEARCH PROTOCOL FOR CHAPTERS 3 & 4: IMPLEMENTATION OF MARINE RESERVES IN THE MIDRIFF ISLANDS REGION, GULF OF CALIFORNIA, MEXICO

A1. Introduction

I am a graduate student under the direction of Professor Leah Gerber in the College of Liberal Arts and Sciences at Arizona State University. I am conducting a research study among key actors of local fishing communities in the Midriff Islands Region of the Gulf of California in Mexico about the different levels of engagement and perceptions towards marine reserves as management tools for marine resources and the ecosystem services they provide. This interview is intended to identify the benefits and the costs of establishing a network of marine reserves in order to protect and restore the natural capital (natural resources viewed as means of production of goods and ecosystem services) within the Midriff Islands Region.

A2. The Study

The purpose of the study is to explore the different levels of engagement and perceptions towards marine reserves, as management tools for marine resources and the ecosystem services they provide, among key actors (stakeholders) that fish in the Midriff Islands Region in the Gulf of California, Mexico through an interview process. Conservation and fisheries management efforts to establish marine reserves often fail to include local communities in the design and implementation of the reserves and their management regulations. In order to analyze these interactions at a local scale, this empirical study will examine the following questions: A) What is the level of understanding and support for marine reserves among key actor groups?, and B) How does this support vary among these groups?

A3. Methods

I am inviting your participation, which will involve an interview of 52 short questions that will last a total of 1hr to 1hr & 30 minutes. I will read the questions to you and you can answer at your own pace while I write the answers. There will be some spatial questions in which I will ask you to draw specific polygons in a map. I would also like to record the interview to make sure I capture all the necessary information. You can also choose to stop the recording at any point. You have the right not to answer any question, and to stop participation at any time.

A4. Confidentiality and Anonymity

Your responses will be kept confidential, and your name will not be used as I am obligated to maintain the anonymity of all participants. I will process the physical copies of the interviews into an electronic database myself, and I will assign unique code identifiers for each interview to maintain anonymity. The data will be stored, processed, analyzed, and transmitted using only the unique codes as identifiers in order to protect the confidentiality of the respondents' answers and their identity. I am the only person who will have access to both the physical and electronic copies of the interviews in a password-protected electronic database on a secure ASU server (Gerber Lab server) until Summer of 2017. The data will only be analyzed and utilized for the purposes of scientific research.

A5. Participation and Information Sharing

Your participation in this study is voluntary, and you have the right to refuse to participate before or during the research process. The results of this study may be used in reports, presentations, or publications by myself. Your responses to the interview will only be used for scientific research purposes, and although there is no direct benefit to you, possible benefits of your participation include a better understanding of your point of view on the topic of marine reserves as management tools for fisheries and biodiversity in the Midriff Islands Region. A better understanding will help us make better recommendations for management strategies in the future, thus your participation is very valuable for the success of the fisheries in the region and the conservation of its biodiversity.

If you have any questions concerning the research study, please contact the research team at: (Mar.Mancha@asu.edu, Leah.Gerber@asu.edu). If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788. Please let me know if you wish to be part of the study.

EXEMPTION GRANTED

Leah Gerber Life Sciences, School of (SOLS) 480/727-3109 Leah.Gerber@asu.edu

Dear Leah Gerber: On 4/20/2015 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Interview to identify the degree of acceptance towards the implementation of a network of marine reserves (no-take zones) in the Midriff Islands Region, Gulf of California, Mexico
Investigator:	Leah Gerber
IRB ID:	STUDY00002571
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Gerber_Mancha_Recruitment Script, Category: Recruitment Materials; • Gerber_Mancha_Recruitment Script ENGLISH, Category: Recruitment Materials; • HRP-502c - Consent Form (short), Category: Consent Form; • HRP-502c - Consent Form (short, ENGLISH), Category: Consent Form; • HRP-503a - Social Behavioral Protocol, Category: IRB Protocol; • Certificate of Translation, Category: Translations; • Interview, Category: Translations; • Interview, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 4/20/2015.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

APPENDIX E

INTERVIEW TO IDENTIFY THE DEGREE OF ACCEPTANCE TOWARDS THE IMPLEMENTATION OF A NETWORK OF MARINE RESERVES IN THE MIDRIFF ISLANDS REGION, GULF OF CALIFORNIA, MEXICO

1. General context

1.1. What is your perception of:

- 1.1.1 - The current state of marine biodiversity (species/habitats/ecosystems) in the Midriff Islands Region?

  Very bad (4) - Bad (3) - Stable (2) - Good (1) – Very good (0)
- 1.1.2 - The current state of fisheries (commercially valuable species) in the Midriff Islands Region?

  Very bad (4) - Bad (3) - Stable (2) - Good (1) – Very good (0)

1.2 - What factor(s) (or threat(s)) can affect (or are already affecting) the following:

- 1.2.1 - Marine biodiversity (species/habitats/ecosystems) in the Midriff Islands Region?
- 1.2.2 - Fisheries (commercially valuable species) in the Midriff Islands Region?

1.3 - What methods or management tools would you suggest to:

- 1.3.1 - Achieve the protection (conservation) of natural resources (biodiversity - species/habitats/ecosystems-) in the Midriff Islands Region?
- 1.3.2 - Achieve the maintenance of species with commercial value (sustainable fishing) in in the Midriff Islands Region?

The answers to the following questions (1.4.1 – 1.4.3) will be written in Table 1.4 below:
1.4.1 - Do you know which are the Marine Protected Areas in the Midriff Islands Region?
1.4.2 - Do you consider them to be successful for the conservation of biodiversity?

Yes (2) – I don't know (1) – No (0)

1.4.3 - Do you consider them to be successful for the maintenance of fisheries?

Yes (2) – I don't know (1) – No (0)

Table 1.4 - Answers to be written by the interviewer:

Marine Protected Area (MPA)	**1.4.1.(A-C) Interviewee aware that MPA exists**	**1.4.2.(A-C) Biodiversity conservation**	**1.4.3.(A-C) Maintaining fisheries**
	Yes (1) – No (0)	Yes (1) – I don't know (1) – No (0)	
A - Parque Nacional Archipiélago de San Lorenzo			
B - Reserva de la Biosfera Bahía de los Ángeles y Canales de Ballenas y Salsipuedes			
C - Reserva de la Biósfera Isla San Pedro Mártir			

1.4.4 - Why? Explain.

The answers for the following questions (1.5.1 – 1.5.3) will be written in Table 1.5 below.
For each of the Marine Protected Areas that you know exist in the Midriff Islands Region:
1.5.1 – How frequently do you fish within 1km off the border of the marine reserve?
Never (0) – Rarely (1) – Every once in a while (2) – Often (3) – Almost always (4)

1.5.2 – Do you think there is a lack of compliance with respect to the rules of marine reserves (no-take zones)?
Yes (1) – No (0)
1.5.3 – How frequently do you observe that there is a lack of compliance with respect to the rules of marine reserves (no-take zones)?
Never (0) – Rarely (1) – Every once in a while (2) – Often (3) – Almost always (4)

Table 1.5 - Answers to be written by the interviewer:

Marine Protected Area	**1.5.1.(A-C) Frequency fishing nearby** (0 – 4)	**1.5.2.(A-C) Non-compliance** Yes (1) – No (0)	**1.5.3.(A-C) Frequency of non-compliance** (0 – 4)
A - Parque Nacional Archipiélago de San Lorenzo			
B - Reserva de la Biosfera Bahía de los Ángeles y Canales de Ballenas y Salsipuedes			
C - Reserva de la Biósfera Isla San Pedro Mártir			

1.5.4 – If the answer to question 1.5.2 is Yes, why do you think there is non-compliance with the rules for marine reserves (no-take zones)?

1.6 – If the answer to question 1.5.2 is Yes, and considering that there are _____(# of fishermen specific to the community being interviewed)_____fishermen in the community of ______(community where interview is taking place)______: In your opinion, what percentage of fishermen would you say do not comply with the rules for marine reserves (no-take zones)?

1.7 - What do you think should be incorporated or improved so that the Marine Protected Areas in the Midriff Islands Region can achieve the following objectives:

- 1.7.1 - Protect (conserve) the natural resources (biodiversity – species/habitats/ecosystems)?
- 1.7.2 - Maintain commercially valuable species (sustainable fisheries)?

2. Marine reserves
2.1 - Do you know what is a marine reserve (no-take zone)? Yes (1) - No (0), define it.

2.2 - Do you know what is a network of marine reserves (no-take zone)? Yes (1) - No (0), define it.

2.3 – Considering the list of natural capital elements listed in Table 2.3, for which of those would you consider that a marine reserve (no-take zone) is an adequate tool for helping protect the natural capital (natural resources) that exist in the region you live in? Use Table 2.3 that has been provided to you:

Table 2.3 – Natural capital
(at the end)

2.4 – Of those elements that you chose in Table 2.3 that you consider important, what total percentage of each one would you like to have the protection of a marine reserve? Uste Table 2.3.

2.5.1 – If in Table 2.3 you selected "commercial species", which are these species?
2.5.2 – On average, how much (in kg) do you catch of each species?
2.5.3 – What fishing gear do you use for each species? And if your boat operates with more than one person, how many?
2.5.4 – What is the commercial value of each species?

2.5.1 – Species (or common name)	2.5.2 – Catch (kg)	2.5.3 – Fishing gear	2.5.4 – Commercial value

….

2.6 - What are the benefit(s) of protecting natural capital that you consider important in the Midriff Islands Region?

2.7.1 - Who do you think benefits from a network of marine reserves in the Midriff Islands Region?
You, but not others (3) – Others, but not you (2) – You and others (1) - Nobody (0).
2.7.2 - List the coastal communities referred to as "others".
2.7.3 - Please explain your answer in 2.7.1.

2.8.1 - Based on the presence of natural resources that you consider important, what is or what are the most important sites (both with respect to biodiversity conservation as well as for the maintenance of fisheries in the Midriff Islands Region? Use the maps provided to draw the sites (there is no need to limit the number of sites).
2.8.2 - What is the importance (as a percentage) that you would give to these sites? Using the 100 seeds provided to you, assign a number of seeds to each site based on its importance.

2.9 Using the map, indicate which of those important sites (from 2.8.1) do you think should be protected? (there is no need to limit the number of sites).

2.10 Indicate on which of those sites (from 2.9, that you think should be protected) would you be willing to establish a marine reserve (whether the reserve is managed voluntarily or through the corresponding authorities)? Use the map provided to you (there is no need to limit the number of sites).

2.11.1 - Thinking of those sites (from 2.10) where you would be willing to establish a marine reserve:

- Would you be ok with the establishment of a **network** of marine reserves (no-take zones) in the Midriff Islands Region?
  Strongly disagree (0) – Disagree (1) – Neutral (2) – Agree (3) – Strongy agree (4)

- 2.11.2 - Why?
- 2.11.3 - How long (in years) do you think it would take to accomplish the establishment of a network of marine reserves in the Midriff Islands Region?
- 2.11.4 - How long (in years) would you like this process to take (i.e. having the network of marine reserves in the Midriff Islands Region estblished)?

2.12 - Which of these management tools do you prefer for the establishment of marine reserves? Higher to lower preference (2 – 1 - 0)

2.12.1 - Marine reserves through community agreements	
2.12.2 - Marine reserves through CONAPESCA	
2.12.3 - Marine reserves through CONANP	

2.13.1 – From your perspective and considering the whole region of the Gulf of California, what are the top 5 sites for best fishing? Use the maps provided (2.13.A-F) to draw the sites.
2.13.2 – What importance (in percentage) do you give to each of these sites?

2.14.1 If your productive activity were to be affected (e.g. less sites for fishing) by the establishment of a network of marine reserves in the MIR, do you have the option of engaging into another way of making a living (i.e., an "alternative livlihood)?

Yes (1) - No (0).

2.14.2 - In case of the answer to 2.14.1 being "Yes", What would it be?

3. Social relations

3 - List the principal organizations (government agency/academia/social civil organizations/non-governmental organizations) involved in the conservation of biodiversity and maintenance of fisheries and answer the following questions with respect to your relationship with such organizations:

(The answers to the following questions will be written by the interviewer on Tables 3.1 and 3.2.

3.1.1 – List of organizations
3.1.2 – Would you consider that you hold a positive (1) or a negative (0) relationship with such organizations?
3.1.3 – How would you characterize the intensity of collaboration between you and such organizations?
Very low (0) – Low (1) – Moderate (2) – High (3) – Very high (4)
3.1.4 - How would you characterize the reciprocity of collaboration between you and such organizations (i.e. do you think they help you as much as you help them)?
Never (0) – Rarely (1) – Every once in a while (2) – Often (3) – Almost always (4)
3.1.5 - How would you characterize the level of trust between you and such organizations?
Very low (0) – Low (1) – Moderate (2) – High (3) – Very high (4)
3.1.5 - Would you say that the objectives of such organizations are in agreement with your own objectives?
Yes (1) – No (0)

Table 3.1 - Biodiversity conservation organizations (at least 3):

3.1.1 - Name	3.1.2 Type + / - (1 / 0)	3.1.3 Intensity (0 – 4)	3.1.4 Reciprocity (0 – 4)	3.1.5 Trust (0 – 4)	3.1.6 Agreement with objectives Yes (1) – No (0)

Table 3.2 - Maintenance of fisheries organizations (at least 3):

3.2.1 - Name	3.2.2 Type + / - (1 / 0)	3.2.3 Intensity (0 – 4)	3.2.4 Reciprocity (0 – 4)	3.2.5 Trust (0 – 4)	3.2.6 Agreement with objectives Yes (1) – No (0)

3.3 – Have you ever participated in a capacity-building workshop sponsored by any conservation or fisheries management organization? Yes (1) - No (0).

If the answer to question 3.3 is Yes, how has your perception / degree of understanding about the use of marine reserves changed for:
3.3.1 – Conservation of marine biodiversity?
Not at all (0) – Very little (1) - Somewhat (2) – A lot (3) - Completely (4)
3.3.2 – Fisheries management?
Not at all (0) – Very little (1) - Somewhat (2) – A lot (3) - Completely (4)

APPENDIX F

ADDITIONAL FIGURES FOR CHAPTER 4

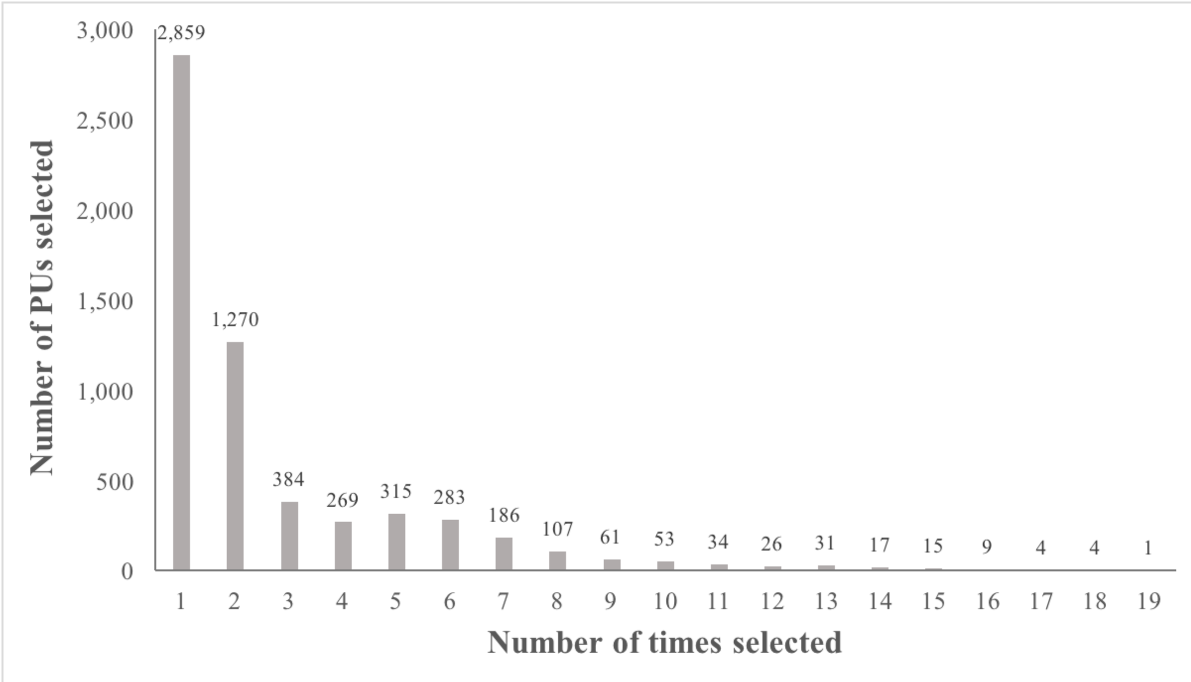

Figure 1F. Selection frequency histogram of planning units selected by fishers in the stakeholder-based approach (A2). PU = hexagonal planning unit of 1 km^2. For example, 1 PU was selected by 19 fishers, 4 PUs were selected by 18 fishers, etc.

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